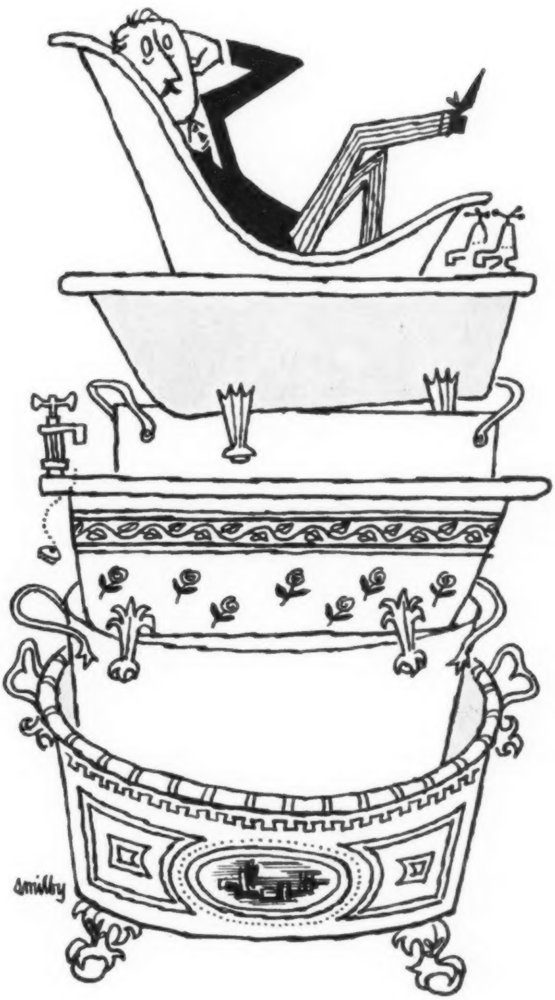
metal finishing journal

PAINT APPLICATION, ELECTRODEPOSITION, VITREOUS ENAMELLING, GALVANIZING, METAL SPRAYING and all METAL FINISHING PROCESSES.

Vol. 7 No. 74 (New series) FEBRUARY, 1961

Vague about vitreous enamelling?



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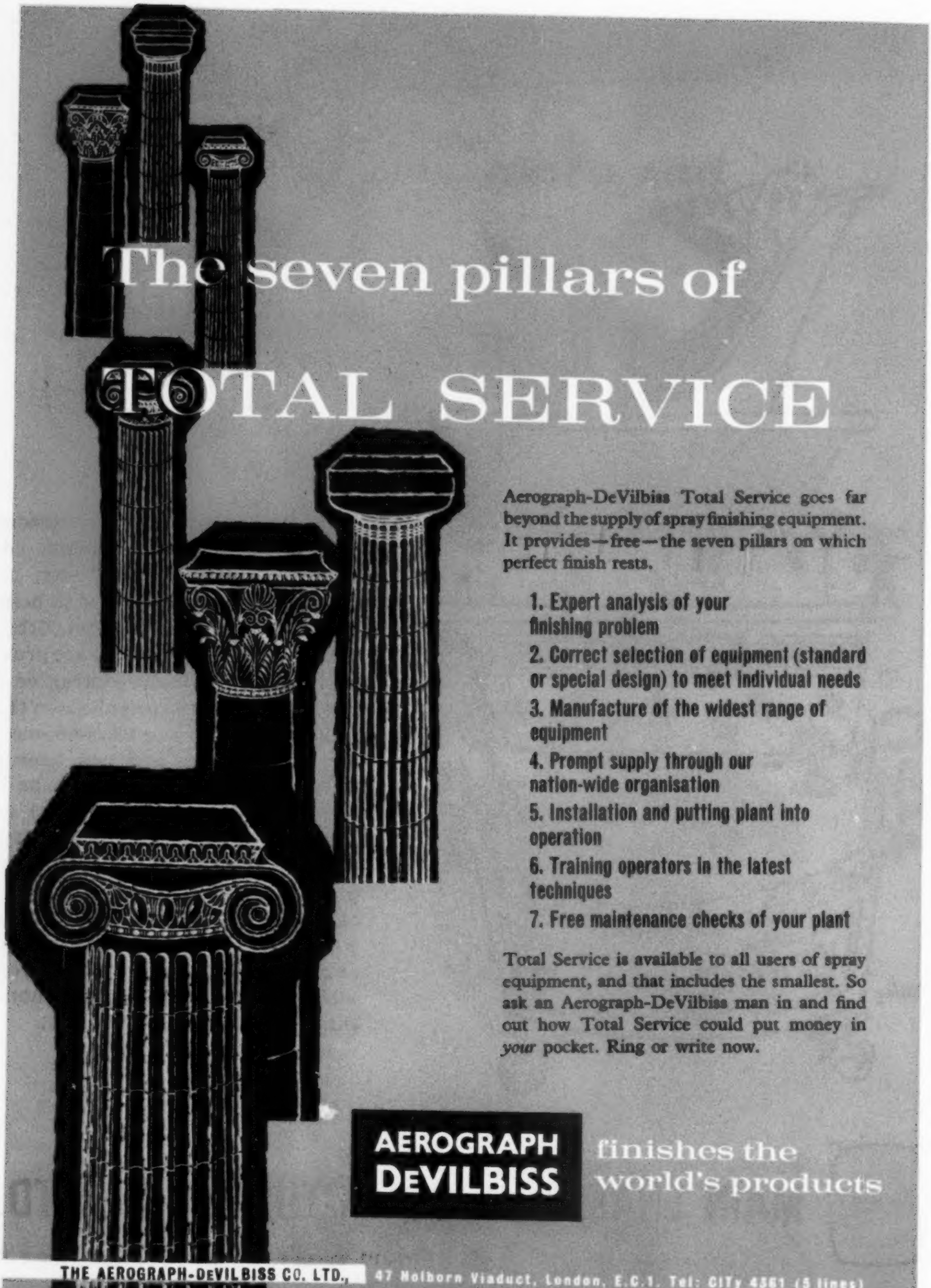

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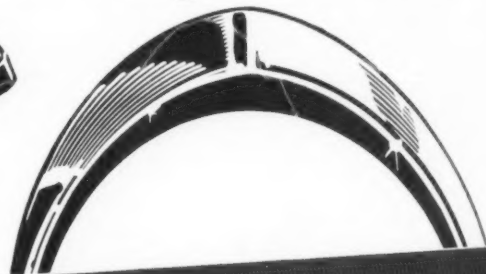

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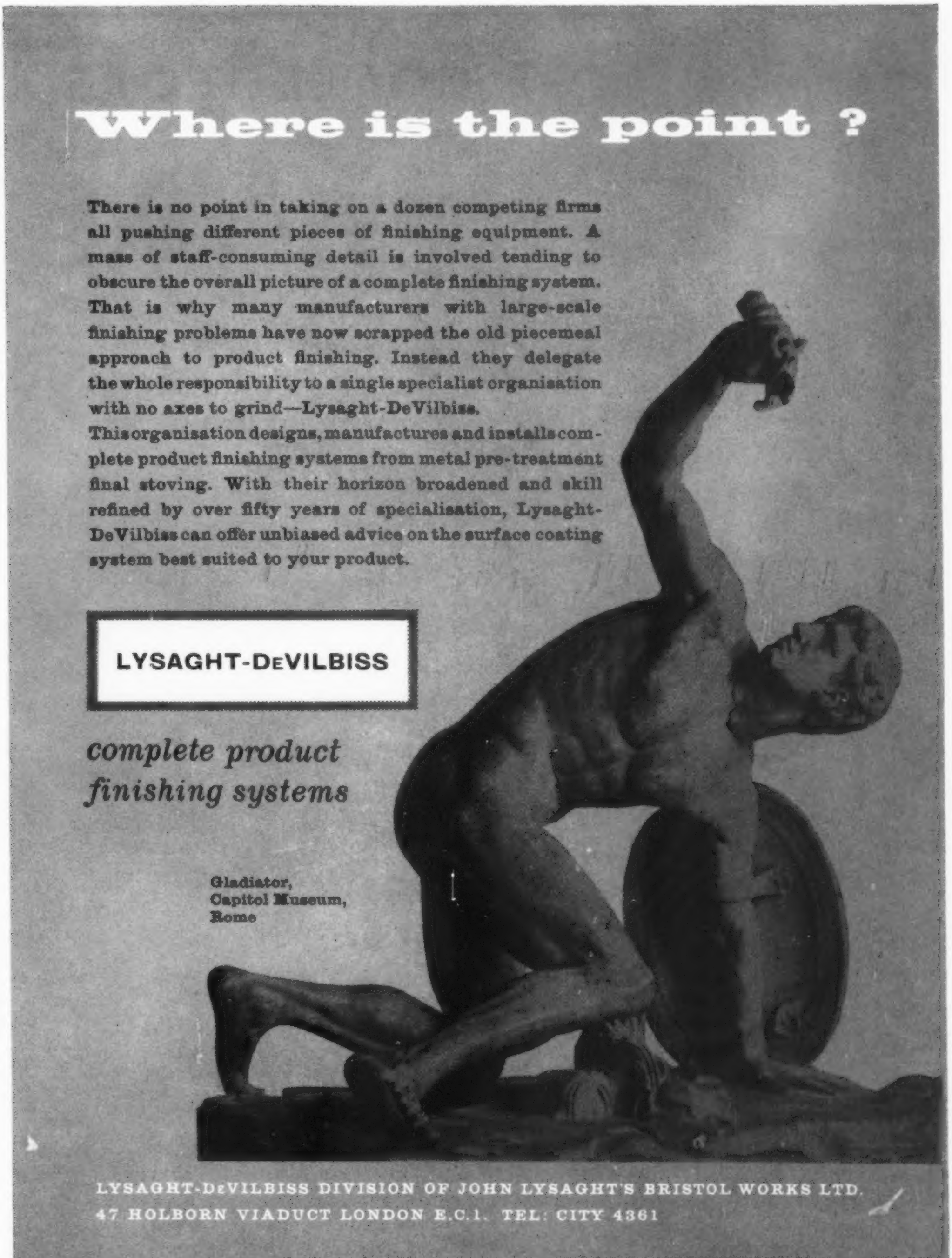
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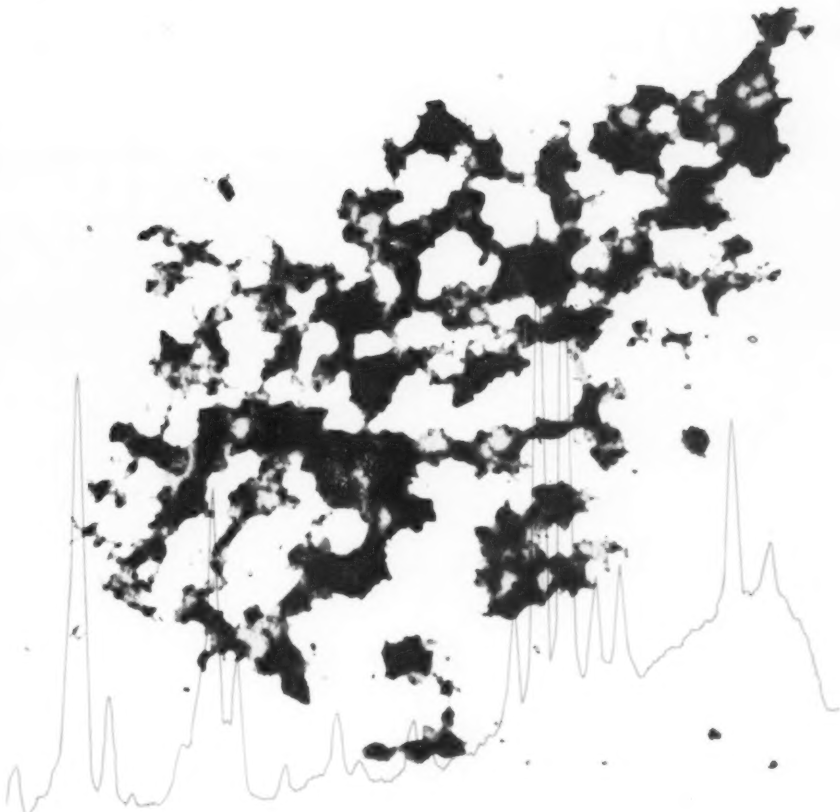

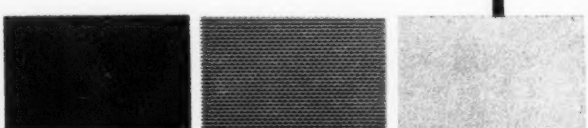

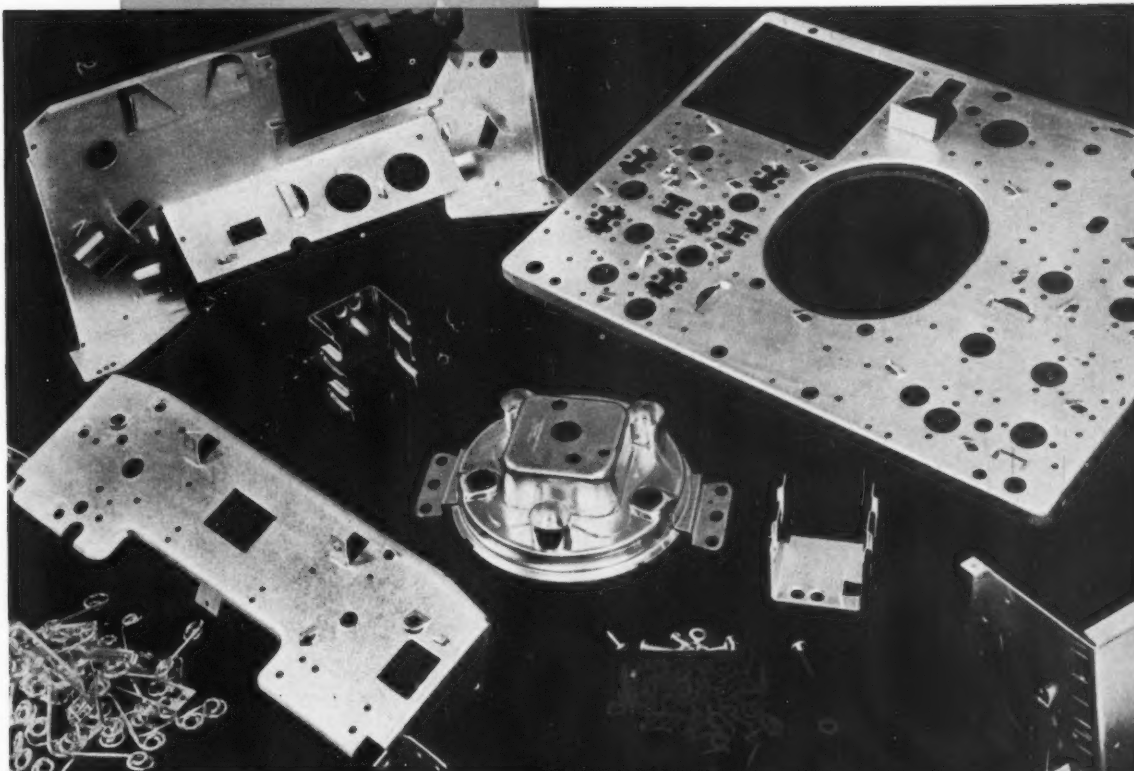

In

Vitreous

Enamelling

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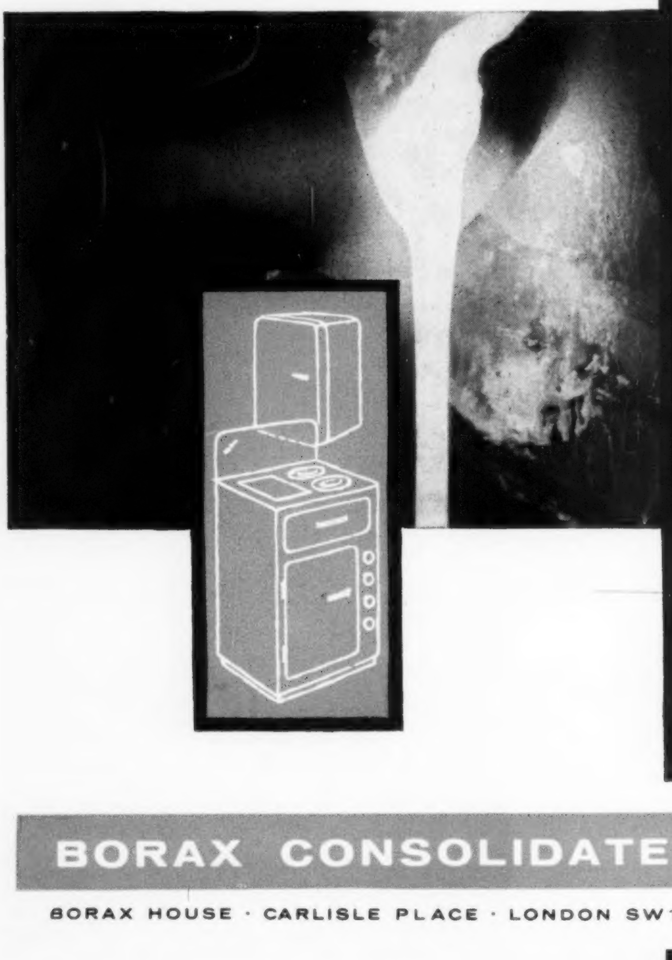

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metal finishing journal

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The only force which can effectively contribute to our continued prosperity is sales force, and the three factors which under present-day marketing conditions have the greatest influence on sales are quality, delivery and price. The finishing process can have a significant effect, either favourable or adverse on all three of these.

About quality, a great deal has been both spoken and written, with, we may dare to hope, the desired result that the necessary action to ensure the maintenance of adequate quality in finishing is being taken.

Delivery is largely a matter of internal administration and organization coupled with the far-sighted (or even possibly clairvoyant) deployment of capital equipment and manpower.

Price is, or should be, a direct function of production costs and the operation of a plant so as to produce a finished component at the lowest possible cost consistent with quality, should be as much the concern of finishing executives as is the analysis of their bright nickel solutions or the viscosity of their paint. The technical bodies catering for the different branches of the finishing industry, while producing excellent programmes of papers on scientific and technical themes, appear to regard the whole question of the economics of processing as belonging to some sordid commercial world with which it is impossible to have contact without contamination. We would suggest that there are very many aspects of the economics of production which could be most valuably discussed by such bodies without in any way their venturing into fields not consistent with their avowed aims.

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Talking Points

by "PLATELAYER"

TOPICAL COMMENT FROM THE MAIN LINES AND SIDE LINES OF METAL FINISHING

QUIET, PLEASE!

NOISE in factories is only just beginning to be recognized as a problem which can be dealt with. It would probably be right to say that in the case of the vast majority of factories now in use, or being planned, the question of noise control has scarcely been given a thought. This is perhaps partly because of a lack of knowledge of the subject on the part of those concerned with factory construction and design, and also to some extent to the fact that there is a natural reluctance to add to the cost of a building by including what might be regarded in many quarters as unnecessary refinements. Of course, if neighbours are likely to complain of noise nuisance, steps may well be taken to improve matters, but the inmates of the building are usually left to fend for themselves.

Yet a noisy environment has not only been shown to be psychologically undesirable, but permanent damage to hearing can result from exposure to high noise levels for long periods. Damage is most likely to occur if the level in any octave band between 300 and 4,800 cycles exceeds 95 decibels. The higher frequencies are the worst. Above 130 to 140 decibels actual pain is experienced. It is interesting to note that damage is more likely to occur if the background noise contains a pure tone or a narrow frequency band, such as the whine of a machine.

Fortunately, most metal-finishing processes are almost silent, but many of the related operations are not. Anyone bothered by the problem could usefully spend a little time with a new Government publication which gives much information on practical measures which can be taken to reduce noise levels in factory buildings.

MASTERS AND MEN

THE object of having University degrees with appropriate letters to put after their owners' names is, in the last analysis, a device designed to save time and trouble. It is much easier to assume, for instance, that a B.Sc. knows more about science than a non-B.Sc., than to attempt to weigh up the respective individuals for oneself. Like all labelling systems, it has its limitations, and only the University hierachy and the ill-educated treat degrees as infallible hall-marks of ability.

At any rate, the system is relatively simple and it is not difficult to understand what the various initials signify.

In the United States, however, according to a recent report of the Office of Education, things have got out of hand. There are, for example, no less than 348 degrees in engineering, including such remarkable variations as Master of Engineering Sciences, Master of Science in Engineering and Master of Science in Engineering Science.

Compared with this kind of confusion, the problem of the difference between a D.Sc., and a Sc.D. is a very simple one.

ANOTHER REASON

ONE rather tends to think of organic coatings as primarily intended either for protection against corrosion in the case of metals, or for decoration where wood or similar materials are concerned. It is therefore a little surprising occasionally to come across an application which comes into neither category. For example, why would anyone want to dip-coat glass bottles with a polyvinyl chloride plastisol?

The answer is surprisingly simple. Glass bottles are now being used as aerosol containers, presumably in an effort to combat the inroads which aluminium and tinplate have made into the container field as a result of the advent of this type of pack. Also, there are some materials which are better stored in glass than in metal.

The plastic coating is intended as a safety measure, and serves to hold the glass together in the event of the container shattering if excess pressure should build up inside it for any reason.

It is expected that Rockware Glass Ltd., the manufacturers, will be plastic dipping upwards of 100,000 bottles a week.

VOLUNTARY OR INVOLUNTARY?

"WHILE there has been no official control on the export of sheets, at Government request the British sheet makers have agreed to a voluntary restriction, so long as the shortage in the home market exists."

Mr. Richard Summers, Chairman of John Summers & Sons Ltd.

"One of the objects of the Company is to revive and to expand the traditional export trade of South Wales in steel sheets . . ."

Mr. Harald Peake, Chairman of The Steel Company of Wales Ltd.

The export drive can take some strange forms!

The Purpose, Theory and Application of NICKEL DIP*

By N. S. C. MILLAR†

Introduction

THE use of nickel dip now covers a span of 15-20 years and there are several references to this subject in the technical literature.

In the group of companies with which the author is associated nickel dip or nickel flash has been in operation for 12 years and this paper describes the theory, practice and applications of the process.

Purpose of Nickel Dip

In conventional two-coat enamelling *i.e.* soft groundcoat followed by covercoat, the use of nickel dip is essentially to permit greater latitude or tolerance in the general enamelling process. The adhesion of the groundcoat is improved thereby permitting it to be fired at lower temperatures *e.g.* at the same temperature as the covercoat. It is also reputed that nickel dip will minimize any fishscaling tendencies brought about by the use of inferior steels but the author has not been able to substantiate or refute this statement. It has been shown on several occasions that nickel-dipped sheets did not copperhead, when sheets processed at the same time without nickel dip, showed this defect.

In the case of fully acid-resisting blacks or A.R. self-mottle enamels applied direct to the steel it has been found imperative to employ nickel dip to achieve the desired adhesion consistently. It appears as though the titanium oxide smelted into such enamels to improve acid resistance or co-milling a superopaque titanium enamel with a black, causes a weakening of the enamel/metal bond thus necessitating nickel dip.

Several investigators are attempting to apply covercoat superopaque enamels direct to steel, with varying degrees of success and in this application nickel dip is again essential.

Low firing (730-760°C) groundcoats and covercoats also require nickel flash to obtain consistent good adhesion.

It is well known that cobalt, and to a lesser extent nickel, cause enamels to adhere to pickled steel when smelted in, and the explanations for this fact are many and varied. Until recently, possibly the most commonly accepted explanation was the dendritic theory. This involves an oxidation/reduction process whereby metallic cobalt is formed in the shape of dendrites or needles which, together with the sheet iron, form a couple with preferential etching of the iron, forming "anchor points" into which the enamel flows. Whether such a couple could operate at the firing temperature of 800°C. or so, is debatable. Professor A. I. Andrews at the 1959 I.V.E. Annual Conference outlined several theories all of which had certain merits but no single one was wholly true. It is therefore probable that several reactions occur during the firing of cobalt-containing groundcoats and the true mechanism of adhesion lies in a combination of several theories. Nevertheless until recently it has always been held that adherence agents cobalt or nickel must be present to confer adequate enamel/metal bond. It is known that the adherence-promoting agent is not necessarily in the frit *e.g.* if a clear frit to which a mill addition of adequate nickel oxide is made, it will fire out at about 900°C. and good adhesion will result.

Another factor influencing enamel adhesion is the extent of solution by the enamel of the iron oxides formed during the firing process. It can be appreciated that such oxides are formed on the sheet during the firing until the porous biscuit fuses, thereby preventing further atmospheric oxidation. A soft groundcoat will readily absorb all these oxides formed at the firing temperature but acid-resisting finishes generally have a smaller capacity for dissolving them. If all the iron oxides are not taken up in the enamel a poor bond results and copperheading will probably occur. The use of nickel dip retards or controls the oxidation thereby permitting the A.R. enamel to dissolve all that is formed with the consequent improvement in adhesion.

In the absence of nickel dip it would probably be necessary to increase the firing temperature to dissolve the iron oxides but this in turn would

*A paper presented to the Southern Section of the Institute of Vitreous Enamellers.

†Radiation Enamels Ltd., Warrington, Lancs.

increase the amount of oxides formed thereby causing a vicious circle.

Theory of Nickel Dip

There are two practical means of applying a flash coating of nickel to sheet steel, namely the galvanic or replacement method and the chemical reduction process. The former is by far the more common method in this country and involves straightforward replacement of iron by nickel. This process is similar to the simple schoolboy experiment of immersing a strip of iron in a copper-sulphate solution (preferably acidified) when, after a short time a coating of copper is apparent on the iron. Replacement of one metal by another in this way is dependent upon the relative position of the metals in the electromotive series whereby an element having a more negative electrode potential will replace another having a more positive potential.

Table I

Ion	Electrode Reaction	Electrode Potential
Fe^{++} (ferrous)	$\frac{1}{2}Fe = \frac{1}{2}Fe^{++} + e$	0.441
Ni^{++} (nickel)	$\frac{1}{2}Ni = \frac{1}{2}Ni^{++} + e$	0.231
Fe^{+++} (feric)	$\frac{1}{3}Fe = \frac{1}{3}Fe^{+++} + e$	0.045
H_2 (hydrogen)	$\frac{1}{2}H_+ = H^+ + e$	0.000
Cu^{++} (copper)	$\frac{1}{2}Cu = \frac{1}{2}Cu^{++} + e$	−0.344

From Table I it is apparent that before nickel will replace iron, the iron surface must be in the ferrous state as distinct from ferric. The amount of nickel deposited on the sheet is dependent upon the *p*H of the nickel salt solution (usually nickel sulphate) its temperature, concentration and the period of immersion.

In the chemical-reduction process nickel is deposited on to the sheet steel by reducing the nickel in the solution (again usually nickel sulphate) to metallic nickel by means of reducing agents, the most common one being sodium hypophosphite, sodium acetate being added as a buffer. Nickel can be deposited onto several metals by this means, the metal being a catalyst to initiate the reaction. If the temperature of the solution exceeds approximately 140°F. nickel is precipitated spontaneously *i.e.* in the absence of any catalyst.

The nickel deposit by the reduction method is again dependent upon *p*H, temperature, concentration and immersion time.

It is obvious that the container for the nickel solution in both these processes must not be iron.

When nickel is deposited onto sheet iron by either of these methods it is in the form of a thin porous coating. Electrolytically deposited nickel is not porous and cannot therefore be used for effective enamelling. Some twelve years ago, pieces of sheet steel were given a 20-second's immersion in an electrolytic nickel tank and the subsequent acid resistant enamel had fair adhesion but was " patchy " indicating that the thin nickel coating was not evenly distributed over the ware, or that only part of the ware had a sufficiently thin coating to be apparently porous, the rest having a continuous impervious layer. It could not therefore be regarded as a practical proposition.

Practical Application of Nickel Dip

In the plants with which the author has had most experience the pickling cycle which contains a nickel dip (galvanic) is as follows :

a) Trichlorethylene vapour degrease.
b) Orthosil liquid degrease—10 min at 205°F.
c) Flowing water rinse—10 min. at 100°F.
d) 1.5N sulphuric acid—10 min. at 150°F.
e) 1.5N sulphuric acid—10 min. at 150°F.
f) Flowing water rinse—1½ min. at 150°F.
g) Nickel dip 1¾ oz. per gal. $NiSO_4 . 7H_2O$, *p*H 3.5-7½ min. at 175-180°F.
h) ⅛ per cent. cream of tartar rinse—1½ min. cold.
i) 0.03N soda ash neutralizer—7½ min. at 160°F.

The nickel tank is made of iron and is lead lined, the dimensions being 78 in. x 46 in. x 50 in. high and is of 500 gallons capacity. A lead coil of 1½ in. external diameter is used for heating purposes, the steam pressure being 25 to 30 lb. per sq. inch.

One of the most necessary adjuncts to nickel dip is an efficient filtration system to remove the iron hydroxide formed during the process. Initially a filter-type press was employed but this was inadequate and the system now in use is a stainless steel Metafilter. The filter medium is a silicious material—Metasil ; in the 5 sq. ft. Metafilter the Metasil is renewed twice per day, 2 lb. being used each time. The recirculating pump is of such capacity that three changes per hour of solution occur. These conditions are suitable for processing 20,000 sq. ft. of sheet iron daily. Smaller Metafilters are available for processing less ware. Pumping air through the liquor when the plant is not in operation helps to precipitate the iron and is an aid to more effective filtration.

It has been found that if for any reason the pump fails the nickel solution becomes turbid with iron hydroxide and pickling is impossible after approximately five hours. The use of a tartrate rinse after the nickel is recommended as any iron hydroxide floccs inadvertently carried over form soluble iron tartrate resulting in a cleaner pickled sheet and thereby minimizing any copperheading tendency.

The temperature of the nickel sulphate is maintained thermostatically at the required degree $\pm 5°$C. and no attention is necessary.

The concentration of nickel solution is made up twice daily and for practical purposes provided it does not fall below 1 oz. per gallon adequate nickel deposits on the ware. While accurate nickel estimations are carried out periodically on the solution and deposit on the ware a rough method found adequate for maintaining the solution strength is as follows :—

The nickel solution is filtered to remove iron then its colour compared visually with standard solutions containing various known amounts of nickel sulphate.

When nickel dip was first introduced in 1948 considerable effort was exerted to maintain a *p*H of 5.5 but this did not prove effective. Among the methods and materials assessed to raise the *p*H (reduce the acidity) were :—

a) Ammonia.
b) Hydrogen peroxide.
c) Passing liquor over a chalk bed.
d) Passing liquor over nickel carbonate.
e) The use of a plastic, slightly soluble, nickel carbonate.
f) The use of boric acid as a buffer.

Ultimately it was found that at a *p*H of 3.5 to 4.5 a satisfactory deposit was obtained. (It was subsequently found that the addition of ammonia in the presence of ammonium chloride effectively raised the *p*H *i.e.* by the common ion effect). In the literature it is recommended that sulphuric acid be added to bring the *p*H down but it has been our experience that this is not necessary as the liberation of SO_4 from the nickel sulphate solution caused by the galvanic process is such that a *p*H of 3.5 is soon reached and maintains itself at this level.

Over 10 years the nickel deposit has varied from approx. 0.08 to 0.17 gm. per sq. ft. and this has been found adequate for A.R. self mottles and A.R. groundcoats.

Several attempts have been made to increase the amount of nickel deposited and some are listed, together with other factors relevant to nickel deposition.

a) Increasing the acid pickle time and temperature caused no increase in nickel pick-up but did increase the risk of overpickling with the formation of black carbon smut.
b) The use of nitric acid gave a slight increase in nickel deposit but it is probable that the resultant improved adhesion was caused essentially by the deeper etch.
c) Increasing the nickel concentration to 3 oz. per gallon had no effect.
d) Increasing the *p*H showed little effect on nickel pick-up. As mentioned previously it had not been possible to carry out this under production conditions but by taking samples of sheet at frequent intervals from a fresh solution which starts at approximately *p*H 7 then drops to 3.5, the effect was noted.
e) Initially the immersion time was 7½ minutes but this was increased to 9½ min., the resultant nickel deposit thereby being increased about 5 per cent. Due to a mechanical breakdown of the plant, plates were left in the nickel tank for 1½ hours and the nickel deposit was found to be 0.25 as against 0.12 gm. per sq. ft. for 9½ min. immersion.
f) Increasing the nickel solution temperature had more effect than the other variations made. In the particular plant under review the maximum temperature possible was about 170°F. as the rubber stator of the pump was affected at temperatures in excess of 180°F. This result is substantiated by published work using 2 oz. per gallon nickel sulphate at a *p*H of 6.2 and is shown in Table II.

Table II.

Temp °F.	Time (minutes)	Nickel deposit gm. per sq. ft.
150	1	0.046
150	2	0.042
150	4	0.064
170	1	0.059
170	2	0.066
170	4	0.092
190	1	0.074
190	2	0.089
190	4	0.150

g) Variation in the method of packing the plates in the pickle basket had little effect on nickel deposit provided free movement of liquor between the plates is ensured.
h) Initially a cold-water rinse preceeded the nickel tank but this caused variable nickel deposition on the sheet with consequent areas of good and poor adhesion on the same fired enamelled sheet. Replacing this rinse by warm flowing water eliminated the variation. The probable explanation for this was that warm sheets were lowered into the nickel tank thereby permitting nickel to be deposited immediately whereas when cold sheets were immersed the initial rate of deposition was slow but increased as the temperature rose.
Care should be taken however to prevent the plates drying out between the rinse tank and the nickel tank.
i) A most important factor concerning effective nickel deposition concerns the degreasing

stage. If the degreasing is not carried out thoroughly low nickel deposits will result. Greaseburning is a most effective means of removing grease. It is thought however that greaseburning or heat treatment also "activates" the steel thereby rendering it more succeptible to acid pickling with the formation of a better etch and consequent improvement in enamel adhesion.

Nickel Dip by the Reduction Method

It is claimed that this method enables a heavier deposition of nickel to be obtained and the deposit is more even. The author has substantiated the former but has obtained no confirmation that the coating is any more uniform in thickness than using the galvanic process.

The following solution can be used :—

Nickel sulphate ($NiSO_2.7H_2O$)	4 oz. per gallon.
Sodium hypophosphite	4 oz. per gallon.
Sodium acetate	$1\frac{1}{3}$ oz. per gallon.
*p*H	3.5 to 4.5
temp.	120°F.

The nickel deposit using this solution is proportional to the period of immersion and 0.11 gm. per sq. ft. are deposited in approximately six minutes. Varying *p*H, concentration and temperature will also affect nickel deposit. As with the galvanic method the ingredients in the tank must be made up at regular intervals depending on throughput. The *p*H is controlled by additions of acid *e.g.* acetic.

A tartrate rinse subsequent to the nickel tank is again recommended to ensure freedom from insoluble iron floccs.

NITEC

As is wellknown, nickel-coated sheet steel is available under the name of "Nitec" and when the author assessed this material good results were obtained with A.R. self mottles and A.R. groundcoats applied direct to the metal. Before use it is necessary to strip off the protective zinc coating with acid.

De-enamelling of Nickel-Dipped Sheets

It is wellknown that de-enamelling may be carried out in either fused caustic soda or a strong aqueous solution of caustic. In general the latter method is preferred as fused caustic is more dangerous to use and also is prone to cause distortion but economic factors involving the shape of the ware can influence the choice.

The caustic solution is contained in iron tanks and can operate at 125-130°C. The time of immersion for removal of enamel is dependent upon the type of enamel on the plates and its thickness *e.g.* soft groundcoat can be removed in six hours whereas an A.R. antimony enamel may take more than 15 hours. Caustic soda will not remove the nickel film from the sheet and if this film is not removed, then the plate is re-pickled, the acid causes the nickel to peel off. If this nickel sheet lifted by this means is held to the light its porous nature can be observed.

After neutralizing the caustic on the steel sheet with warm sulphuric or cold hydrochloric acid and scrubbing, the nickel is removed by immersion in approximately 3 per cent. nitric acid contained in *e.g.* A.R. Proderite brick tank. Steam is blown into the acid to initiate the reaction which then proceeds rapidly with copious evolution of oxides of nitrogen. Efficient removal of these fumes is necessary and p.v.c. has been found to be a satisfactory material for constructing such a venting system. With freshly prepared nitric acid the nickel is stripped off in 30 seconds or so but as the throughput increases, the immersion time can take 20 minutes. A heavy sludge forms in the acid as the process continues.

The de-enamelled and de-nickled pieces after neutralizing and scrubbing are quite satisfactory for subsequent pickling and enamelling after any necessary "tinkering" rectifications have been carried out. De-enamelled pieces have a deeper etch than normal sheets and this can increase the pick-up of slurry during the swilling operation.

Application of Nickel Dip

Soft Groundcoat

As previously stated the author feels that whenever possible all sheet iron should be nickel dipped irrespective of the enamel applied. The adhesion of soft groundcoat is enhanced thus permitting firing at lower temperatures without loss of enamel bond and in this sense and also as regards holding down copperheading and similar defects, nickel dip can be considered to improve the tolerances in vitreous enamelling.

A.R. Self Mottles

Lighter coloured A.R. self mottles can be used on nickel-dipped components than would be possible without this flash. Self mottles which are fully resistant to 2 per cent. sulphuric acid *i.e.* conditions called for in gas cooker interiors and which contain 45 to 50 per cent. of the white frit are in everyday use and these are only possible when a nickel coating between 0.08 and 0.17 gm. per sq. ft. is deposited on the steel.

Grey self mottles of this type are applied by swilling then fired at approximately 840°C. at a track speed of $7\frac{1}{2}$ ft. per min. which is equal to about 4 minutes in the firing zone of the continuous furnace. The fired thickness in one coat is 0.004 to 0.005 in. and if necessary one re-dip is permissible It is desirable not to exceed 0.01 in. fired thickness without the risk of chipping occurring but this

maximum thickness is dependent upon the gauge and shape of the ware—sharp convex radii or other designs which are liable to cause chipping necessitate thinner maxima.

When self mottles are swilled care should be taken to avoid swarf or similar foreign matter contaminating the slurry which would otherwise cause blistering and other defects in the fired ware. An efficient means of obviating this risk is by the use of a " Rotospray " whereby the slurry is circulated continuously through a sieve and over a magnet. Rotosprays are also recommended for swilling soft groundcoats for the same reason. Re-coating and re-firing of self mottles causes a worsening of adhesion.

A.R. Black Groundcoats

The same comments for self mottles apply to fully-acid-resistant blacks applied direct to the steel with the exception that the maximum thickness can be raised slightly, this being due to the absence of any superopaque frit having a deleterious effect on adhesion.

Low-temperature Enamels

Low-temperature groundcoats and covercoats firing at 730 to 760°C. have been formulated which possess excellent adhesion on nickel dipped sheets. In the absence of nickel the adhesion is poor using conventional pickling techniques. The advantage of these low firing enamels is the resultant freedom from distortion of the fired ware. It has been shown that certain casings which, when coated with normal 800 to 840°C. firing enamels, the covercoats having expansions in the 280-300 x 10^{-7} range require careful jigging to prevent distortion but when enamelled with these low temperature frits having higher expansions, fire on normal perritts without inducing distortion.

Direct Application of Covercoat to Steel

This application has been the pipe dream of enamellers for many years in that the thinness of enamel coupled with good adhesion would virtually eliminate chipping. Furthermore, if desired, thinner gauge metal could be used to the economic advantage of the manufacturer and also sharper radii and more complex shapes would come within the practical scope of enamellers and hence widen the scope of enamelling work.

Within the last two years the effort to achieve this object has been intensified in this country and the author feels that the pipe dream is now becoming reality.

One essential in this application is the use of nickel dip either by the galvanic or reduction method.

The company with which the author is associated has been investigating direct application whites (or creams etc.) for quite a while and a brief resumé is given.

The object was to obtain a deep etch or sufficient " anchor points " in the steel to permit a fluid enamel to wet the steel and flow into these anchor points thereby achieving good adhesion and at the same time obtain a good fired surface free from black specks or other defects.

A deep etch may be obtained by adding oxidizing agents to the sulphuric pickle acid and several caused black specking to occur, but gave good adhesion.

Two basic enamels were assessed, one firing at 760°C. and the other at 820°C. and it was found that the higher firing frit was satisfactory. In the course of this work many frits were assessed.

Using this 820°C. enamel good results were obtained using an oxidizing agent addition to sulphuric acid employing galvanic nickel dip (0.16 gm. per sq. ft. nickel).

A cycle employing heat treatment and the use of phosphoric acid and reduction nickel dip has also been assessed with satisfactory results and the cycle employed was as follows :—

Trichlorethylene vapour degrease.
Heat treatment at 650 - 700°C. for 3 min. (bluish irridescence).
Orthosil degrease. 1 Normal. 15 min. at 300°F.
Hot water rinse.
25 per cent. v/v phosphoric acid 15 min. at 140°F.*
Water or ¼ per cent. cream of tartar rinse 5 min. at 160°F.
Nickel dip—reduction method.
¼ per cent. cream of tartar rinse 5 min. at 160°F.
0.03 Normal soda-ash neutralizer 7½ min. at 160°F.

The Ray-Davis Citrobond process (Pfizers) in which citric acid is employed is now probably wellknown and consists of—

Efficient alkaline clean.
Hot water rinse.
10 to 15 per cent. citric acid. 10 min. minimum at 200°F. minimum.
Hot or cold-water rinse.
Nickel dip — galvanic (0.07 to 0.10 gm. per sq. ft. nickel).
Cold-water rinse.
Soda-ash/borax neutralizer.

Air is blown into the acid to ensure that ferric citrate is formed and efficient grease removal is imperative. The citric acid must contain at least 10 gm. of iron per U.S. gallon.

Using this process excellent results have been obtained using the above mentioned frit on British enamelling-quality steel. Using Bethnamel steel (0.003 per cent. carbon) excellent results have also

* Lead tanks inhibit the reaction.

resulted and with this steel Pfizers recommend the addition of a small amount of sodium thiosulphate to the acid but this addition is liable to cause overpickling with normal enamelling steel.

The choice of steel is an important factor in one-coat enamelling by any process.

It is also possible to obtain these one coat whites by "aqua blasting" or "vapour blasting" followed by normal acid pickling and nickel dipping.

A sub-committee of the I.V.E., under the chairmanship of Mr. S. E. A. Ryder, is investigating the use of titanium steel for one-coat enamelling and a report on this subject will be issued shortly. Without anticipating this report is can be stated that good results have been obtained.

From this outline of some aspects of direct application of covercoats to sheet iron it can be appreciated that all future developments in the sheet iron vitreous enamelling industry are dependent upon nickel dip and the author cannot overstress the advantages arising from this process.

APPENDIX I

Methods of Analysis

A. DETERMINATION OF NICKEL IN NICKEL-DIP SOLUTION USING DISODIUM ETHYLENEDIAMINE TETRA - ACETATE AND MUREXIDE INDICATOR:

Discussion

The determination is carried out in strongly ammoniacal solution, therefore, citric acid is added to complex any iron present and thus prevent precipitation of the same. Murexide indicator gives a reddish brown colour in the presence of nickel ions, while in their absence, that is after complexing the nickel with E.D.T.A. the colour is violet blue. In the presence of large quantities of ammonium chloride or sulphate the end point is less definite, probably due to reduction of pOH resulting from the common ion effect.

Recommended Method

Pipette 5 ml. of the nickel solution into a porcelain basin, 6 in. diameter, add approximately 1 gm. of citric acid then dilute ammonia solution till exactly neutral to litmus paper ; dilute to approximately 150 ml. Add exactly 10 ml. of concentrated ammonia solution and ½ gm. of murexide indicator. Titrate the solution with $\frac{N}{25}$ E.D.T.A. solution stirring constantly until the neutral brownish colour of the solution changes to bright bluish violet.

Murexide Indicator

0.2 gm. of murexide ground into 100 gm. of sodium chloride until an intimate mixture is obtained.

Making Up $\frac{N}{25}$ E.D.T.A.

7.6 gm. E.D.T.A. dissolved in water and made up to one litre in graduated flask. This should be standardised against a solution of nickel sulphate, made from analar quality material, and containing 1.5 mg. Ni per ml. The procedure for standardizing the E.D.T.A. is the same as described for the estimation of Ni in the Ni dip solution except that iron must be added to the standard solution to simulate conditions met with in the actual determination.

The method is, therefore :—

Pipette 5 ml. of the standard Ni solution into a porcelain basin, add 5 ml. of ferric chloride solution, containing approximately 1 mgm of iron per ml., then proceed as described previously.

Ferric Chloride

2.9 gm. $FeCl_3$ dissolved in water and made up to one litre. 1 ml. contains 1 mg. of iron.

Calculation

5 ml. standard Ni Solution = 7.5 mg. Ni.

Titrate 5 ml. of standard Ni solution against the $\frac{N}{25}$ E.D.T.A. solution.

Let the amount of E.D.T.A. required be x ml.

$\therefore$ 7.5 mg. Ni $\equiv$ x ml. E.D.T.A.

$\therefore$ 1 ml. E.D.T.A. = $\frac{7.5}{x}$ mg. Ni = factor.

When estimating the Ni. in the Ni. dip 5 ml. of solution should be taken.

Let the 5 ml. of Ni solution require Y ml. of E.D.T.A.

$\therefore$ in 5 ml. Ni. solution there are $Y \times \frac{7.5}{x}$ mg. Ni.

In 1 ml. $Y \times \frac{7.5}{5x}$ mg. Ni.

i.e. $\frac{Y \times 7.5}{5x}$ mg. per ml.

Now mg. per ml. of Ni. multiplied by 0.75 = oz. per gal. of $NiSO_4 7H_2O$

$\therefore \frac{7.5Y}{5x} \times 0.75$ = oz. per gal of crystalline $NiSO_4 7H_2O$.

B. DETERMINATION OF NICKEL IN NICKEL DIP SOLUTION USING POTASSIUM CYANIDE.

The following reagents are required :—

Silver Nitrate N/10

Dissolve 16.99 gm. of A.R. silver nitrate in distilled water and make up to 1 litre.

Potassium Iodide

Make up a 25 per cent. solution in distilled water.

Potassium Cyanide N/10.

Dissolve 13.5 gm. of pure potassium cyanide in water, add 5 gm. of potassium hydroxide and make the solution up to 1 litre. The cyanide solution is standardized against the silver nitrate solution.

Standardization of the Potassium Cyanide Solution

50 ml. of KCN solution are diluted to about 150 ml. 5 ml. of the potassium iodide reagent are added and the solution is titrated with the standard $AgNO_3$ solution until a faint, permanent opalescence is obtained. One drop of KCN solution should be sufficient to clear this.

If "x" ml. are required then the normality factor of the cyanide, in terms of the $AgNO_3$, is—

$$\frac{x}{50} \times N/10$$

(1 ml. of N/10 solution = 0.002934 gm. Nickel or
0.01404 gm. $NiSO_4$. 7 H_2O)

Ammonium Citrate Solution

200 gm. ammonium sulphate, 150 ml. concentrated ammonia, 120 gm. citric acid. Dissolve in distilled water and make up the solution to 1 litre.

Procedure

Filter a sample of the nickel solution to be tested to remove any suspended material.

Measure out with a pipette 10 ml. of the filtered solution and dilute to approximately 100 ml. with distilled water. Add 50 ml. of the ammonium citrate solution and then 5 ml. of the standard silver nitrate solution. Both reagents are to be measured out exactly, using pipettes.

2 ml. of the potassium iodide solution are now added and the solution is titrated with the standardized potassium cyanide solution, with constant stirring until the turbidity just disappears.

Calculation

The concentration of nickel in the solution should be converted into ounces of crystalline nickel sulphate ($NiSO_4.7H_2O$) per gallon of water.

(1 mg. of nickel per ml. = 0.75 oz. of crystalline nickel sulphate per gallon).

Calculation

$$x \text{ ml. } \frac{N}{10} \text{ KCN} - 5 \text{ ml. } \frac{N}{10} \text{ AgNO}_3$$

$$= (x - 5) \text{ ml. } \frac{N}{10} \text{ KCN.}$$

$\therefore (x - 5) \times 2.934$ = mg. of nickel per 10 ml. solution.

$$\therefore \frac{(x - 5) \times 2.934}{10} \times 0.75 =$$

oz. of crystalline nickel sulphate/gallon.

C. DETERMINATION OF NICKEL ON STEEL PLATES USING DIMETHYLGLYOXIME METHOD.

Method

The steel plate of known size is cut into pieces of approximately 1 in. square shapes, then placed into a 400-ml. beaker and covered with concentrated nitric acid. When the reaction becomes vigorous (*i.e.* the emission of dense nitrogen dioxide fumes) the liquor is decanted into another 400 ml. beaker. The nitric acid procedure is repeated twice more. The steel squares are then finally washed three times with distilled water.

To the solution add 10 gm. of tartaric acid and 5 gm. of ammonium chloride and then boil cautiously, taking care to avoid spitting. Allow the solution to cool, then by the careful addition of concentrated ammonia neutralize until litmus paper just turns blue. If the solution is strongly alkaline the precipitate tends to dissolve.

15 ml. of a 1 per cent. alcoholic solution of dimethylglyoxime is then added dropwise, stirring the solution all the time. When the precipitation is complete the solution is allowed to stand on the water bath for 4 hours to coagulate.

Finally the precipitate is filtered off at the pump, using a No. 4 sintered glass crucible. Wash twice with water and finally with alcohol. Dry the precipitate for one hour at 110°C. and weigh.

Results

$$\frac{\text{Wt. of nickel glyoxime precipitate} \times 0.2032}{\text{Area of plate in sq. cm.}} =$$

Wt. of Nickel per sq. cm.

APPENDIX II

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WATER TREATMENT AND RECOVERY PLANT

Treatment for Strip-Mill Effluent

THE Abbey Works of the Steel Company of Wales, one of the world's largest steelworks, with an output of approximately 3,000,000 tons of steel a year, not unnaturally has water problems. It became essential to recover as much as possible of the discharged water for re-use in the mill. In modern strip mills the quality of the water must be good, otherwise rolls will not last and minute indentations will be made on the steel strip and affect the quality of the finished work. Thus treatment plant for water recovery has to be carefully designed to meet this problem and to ensure that the water quality is maintained. The Paterson water-treatment plant shown in Fig. 1, treats the effluent from the hot strip mill containing a large quantity of heavy suspended matter and oil, reducing the oil to a negligible quantity and the suspended solids to an average of 14 p.p.m., without filtration.

The hot-returned effluent is pumped from the scale pits direct to a primary sedimentation tank which is divided into six " canals " each about 100 ft. long by 15 ft. wide, equipped with electrically-driven chain-operated flights or scrapers, the upper flights assisting in the movement of the rising oil to the skimmers and the lower scrapers lifting the heavy suspended solids up to a sloping wall to the top of the primary clarifiers, to be deposited on an endless belt discharging by chute to a railway truck for disposal. The oil skimmers, six in number, are adjustable according to the amount of oil contained in the water and discharged into a holding tank from which the oil can be pumped away or removed by mobile tanker.

The effluent then passes through a venturi flume where it is measured and then proceeds to secondary circular clarifiers of the Centrifloc type each 130 ft. diameter. The venturi flume is also used to control automatically the coagulants which are added to the water to assist in the precipitation of the lighter and colloidal impurities. The coagulants are brought by mobile tanker to the chemical house and discharged into holding tanks from which they are pumped to the automatic measuring equipment. The coagulants used are waste products and keep the cost of the treatment to a minimum.

The Centrifloc clarifiers are of the vertical flow type employing a modified sludge blanket with continuous sludge discharge. Their design is such as to ensure effective mixing and flocculation of the effluent before it is collected evenly over the upper surface of the clarifiers through radial launders equipped with hydraulically spaced orifices. Each clarifier has a mechanical mixer, mechanical flocculators, and sludge scrapers to remove the deposits formed on the floor of the tank, all the equipment being operated electrically. The design of the Centrifloc clarifier is such that the amount of slurry discharge is kept low and is as concentrated as is possible. In these works the slurry is discharged to waste without thickening, but if necessary, thickeners can be incorporated and the sludge vacuum dried.

The plant was originally designed for a flow of 18,500 gal. per min. but after completion it was found necessary to impose on the plant an overload of about 30 per cent, so that the final flow through the plant is now of the order of 25,000 gal. per min.

Fig. 1.—Clarification plant at the Steel Company of Wales, showing the Centrifloc clarifiers.

(Courtesy of The Steel Company of Wales Ltd.)

Some Thoughts On The ECONOMIC ASPECT OF METAL SPRAYING

By
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(A paper presented at the Annual Assembly, 1960, *of the International Institute of Welding.)*

AS a rule the adoption of any process for a particular purpose must depend on its ability to satisfy the technical service required in the most economical way.

In this paper it will be assumed that technical requirements have been satisfied so that the economic value only is to be considered. Even with this limitation a considerable number of questions require to be answered. Some must be answered by the customer, that is the man who is to use the process, and some by those working the process. The customers' questions are the most important otherwise the work would not be ordered, but the order having been placed it is necessary for someone to be interested in the most economical production. A treatise upon a process from the angle of economics must cover both types of questions. It is obvious that many economic factors are not the same in every country and any discussion on costs in any country can only be accepted as a guide to the economics of another, even if an exact translation can be made of the various equivalents.

At the present time, in Great Britain, the cost of labour is fairly high and appears to be rising. It has not yet attained the very high levels which are common in America or in Australia but it is well above the labour cost in some other countries. In considering any values given in this paper a comparison must be made by the reader based on the economic terms of his own country (Table I).

Considering the adoption of the metal-sprayed deposits by a customer it is necessary to specify the requirements, *viz* are the deposits to be usedfor :

1.—Anti-corrosive work or heat resistance
2.—Reclamation and building-up
3.—For some special purpose such as the manufacture of moulds or building-up solid bodies.

*Metalisation Ltd.

Table I.

Approximate Average. Hourly rates for metal sprayers and blasters, taken from official returns for first quarter of 1959.

Country	Working week in hours	Exchange per £1.	Hourly rate in local currency	Additions paid by employers, holidays, insurance, etc.	Total hourly rate, local currency	Approximate rate in £'s
Australia	40	—	—	—	—	0.47
Belgium	45	140 B.F.	28	4	32	0.23
Denmark	48	19.34 Kr.	5.4	0.2	5.6	0.29
France	46	1382 francs	186 Provincial rate 280 Paris	85 140	271 420	0.20 0.30
Germany	43	11.76 D.M.	2.32	0.3	2.62	0.23
Great Britain	44	—	0.27	0.03	0.3	0.30
Holland	—	10.57 Hfl.	2.0	0.15	2.15	0.2
Italy	—	1750 lire	219	76	295	0.17
Norway	47	19.8 Kr.	6	3.6	9.6	0.47
Sweden	47	14.48 Kr.		0.2	5 3	0.36
U.S.A.	—	2.8 dollars	2.4	—	—	0.86

Usually in the latter case the actual cost is not important as it is a question of adopting the process to do something which is difficult by any other means. The main uses of metal spraying are not in this category which need not be considered further.

On the other hand the importance of anti-corrosive work makes it imperative to study the many factors involved.

One may take, for example, the metal spraying of a bridge or some such structure. It is now generally realized that the metallic coating is not used as a substitute for a paint finish but it is used as a primer which is subsequently painted. The amount of paint used will be smaller than if the whole protective system is based on paint but nevertheless two or three coats of paint may be necessary after metal spraying. It is now accepted that even if protection by paints alone is to be employed, the steel of the bridge must be thoroughly cleaned. As these structures are usually large, gritblasting seems to be the most reasonable method of attack. It follows, therefore, that the preliminary cleaning which is in itself costly is not very different whether it is to be followed by metal spraying or by painting.

The use of metal spraying requires that grit-blasting has to be used as the cleaning method whereas flame cleaning or even weathering and wire brushing might be tolerable in the case of painting. Sometimes when a structure such as a bridge can be made up of small members, some saving can be achieved by acid pickling especially in phosphoric acid using inhibitors, followed by a phosphating process. Generally speaking this is not a practical proposition on large structures as the thorough washing required presents difficulties. The necessity of leaving members in the open to weather for long periods and the time taken in wire brushing often interferes with the constructional engineers' programme. Flame cleaning is very heavy on acetylene ; its cost shows little economic advantage over blasting which is a process that in the hands of experts is readily adaptable. Flame cleaning can be carried out at rates of about 5 sq. metres per hour and 2 cu. metres of acetylene and 1 cu. metre of oxygen will be required.

The fundamental reason for metal spraying is to reduce maintenance in the years following erection. In countries where labour is plentiful and its cost very low it may still be much cheaper to use the crudest methods of painting and renew the coating continuously. As countries advance in social services the cost of maintenance must rise.

A short working week often necessitates overtime with the usual increments ; these must be considered as a dead charge, and in Great Britain at present these increments together with payments for holidays and the social services often exceed 12 per cent. of the total wage bill. If a pension scheme is also in operation this figure is exceeded.

A case in point is the well known rail bridge over the River Forth in Scotland opened in 1890. This has required continual maintenance by painting and it has been stated that when painting has been completed at one end it is necessary to start over again. When this bridge was first built it would have been difficult to argue that this was not inevitable but now with rising costs it is very undesirable. A new bridge very near to the old one is now being built to carry a road over the river. After due consideration it has been decided that maintenance must be minimized and this bridge is to be zinc sprayed, before painting.

Even now some economists and bridge builders argue that in view of the cost of protective schemes it might still be tolerable to allow for much maintenance. The argument is based on the effect of compound interest ; for instance, 1,000 units of investments may have to carry a loan interest of say 5 per cent. It is well known that if there is no repayment and the interest compounded over 10 years the outstanding amount would be 1,629 units and in 20 years 2,653 units. The argument appears to be fallacious as it must be realized that during the useful life of a structure there is usually a repayment of capital, and depreciation is catered for by a sinking fund. The final outstanding amount at the end of a period is not the original cost. Even so, the cost of capital investment is high and if it is necessary to expend money to get better protection and set this off against maintenance over short periods there may be a little saving. Over longer times the cost of protection is justified.

In 1955 at a Symposium arranged by the Corrosion Group of the Society of Chemical Industry the author gave some figures for specific cases of structural work, a summary of which is given in Table II.

The data was subsequently criticized because the effect of compound interest had not been included. This omission was deliberate because in any such examples all factors cannot be taken into account. For instance, while allowance was made for the cost of scaffolding it was impossible to estimate the cost of dislocation of services often necessitated by frequent painting. Furthermore, it cannot be assumed that corrosion, if allowed to occur, will take place evenly over the structures. It usually is most dangerous at the most inaccessible points. As already mentioned, since 1914 there have been great changes in the value of money and over periods of twenty-fifty years these trends cannot be estimated except that it seems fair to

Table II.

Synopsis of Table Published in " Chemistry and Industry " in 1955 Converted to Metric Measures.

Area of work in sq. metres per 1000 kilogrammes	18.25		27.37 (All costs in £ sterling per 1000 kg.)		31.9	
Method treatment	A	B	A	B	A	B
C. initial cost	7.18	11.47	10.78	17.22	12.54	20.07
D. repainting scheme	21.75	34.00	31.10	50.88	36.62	59.25
Total cost over 50 years	28.93	45.47	41.88	68.10	48.86	79.32
E. alternative painting Scheme	24.07	37.88	36.02	57.08	42.02	66.14
Total cost over 50 years	31.25	49.35	46.80	74.30	54.56	86.21
F. Metal spraying scheme						
Total cost over 50 years	29.88	37.59	44.72	56.29	52.21	65.55
G. Mechanised metal spraying scheme						
Total cost over 50 years	23.96	31.74	35.68	47.24	42.82	56.20
Saving shown by mechanical spraying over cheapest alternative 50 years approx.	£5	£14	£6	£21	£6	£23

A. based on painting costs of £0.1 per sq. metre.
B. based on painting with best red-lead primer. £0.167 per sq. metre.
C. preparation by mechanised brushing and some hard brushing at contractors works, one coat of primer at works, staging and one intermediate and two finishing coats on site.
D. repainting scheme, staging, cleaning, touching up, one coat of paint carried out every four years *i.e.* 12 times in 50 years.
E. alternative repainting scheme, staging, two coats of paint, 8 times in 50 years.
F. metal spraying scheme, manual method in works, blasting and spraying with zinc or aluminium, staging on site and one coat of paint and repainting scheme with one coat, 6 times in 50 years.
G. metal spraying by mechanical plant, carriage to plant, staging on site, one coat of paint and repainting scheme as before.

expect that costs of repainting will be increasing. (Table III).

However, it is interesting to note what the effect of depreciation and compound interest worked out by the standard formula can be at the worst. Examples are given in Table IV worked out at interest rates of 5 per cent.

Table III.

Depreciation of money values.	Value of £1.
Year 1914	£1 as basis
1939	£0.63
1946	£0.41
1959	£0.253

Table IV.

Annual costs of schemes in £ sterling calculated by dividing total costs given in Table II by 50.

	A	B	A	B	A	B
Scheme D.	0.58	0.91	0.84	1.36	0.98	1.59
G.	0.48	0.64	0.71	0.95	0.86	1.12

Annual costs taking into account depreciation and compound interest on investment. Depreciation being on original costs.

Scheme D.	0.82	1.31	1.21	1.96	1.41	2.3
G.	0.94	1.32	1.40	1.68	1.69	2.0

When the work is not a bridge but a factory structure, other important points have to be considered, for instance, the necessary maintenance may stop production and this may bring about a considerable loss of output. It is believed that such considerations outweigh the cumulative effect of interest and it is now accepted that the metallic coatings can definitely show great savings over a period of 20 years especially in industrial and marine atmosphere and conditions of immersion. Atmospheric corrosion is dependent on humidity and on atmospheric polution especially where there is sulphurous contamination. In Great Britain humidity is usually high. In many areas there is industrial activity and great interest is now being shown in the protection of structures by metal coatings. In places between wind and water where there is dangerous local corrosion and methods of cathodic protection do not apply, metal coatings are essential.

With regard to factory structures there is another point of utmost importance. It was stated by an engineer of a works that as he did not expect his structures to be suitable after 20 years he did not even worry to paint them and so saved capital cost. At one works where this system was adopted in about the same period the building became unsafe and its value was reduced to that of a write-off. If on the other hand a building is erected and properly protected then at the end of 50 years it has a re-sale value, which judging from the

present time, owing to the change in value of money might even be greater than the original cost of the building. It must be remembered that if metal spraying with aluminium is adopted as a protection and it is not coated with paint, reasonable protection even in adverse conditions can be expected over 15 years. If, on the other hand, the coating is painted possibly every 8 years (the painting being much easier because no cleaning is necessary) complete protection can be easily obtained for much longer periods than 50 years; also the building will maintain its value.

The argument for the metal spraying of constructional work is also valid for ships and tankers. It is now general practice in many countries to gritblast the internal surface of tankers and to protect those surfaces by applying one of the newest synthetic enamels (often with an epoxy base) or by using inorganic compositions. There is no doubt that this treatment does give good service but there is ample evidence that if the basic steel is sprayed with aluminium the protection given by the subsequent plastic material is very much improved and the enamel coating may be unnecessary in some areas. The cost of applying the plastic materials is usually about one quarter of the cost of blasting in ship work, arrangements for scaffolding being common to both.

Summing up there would seem to be no doubt that an extremely strong case can be presented, and is usually accepted for the use of metallic coatings on large structures of many types.

When reclamation is considered the possibilities of saving money by metal spraying are even more apparent, as parts can quite easily be salvaged at costs which vary from 2 per cent to 10 per cent. of their original value. For instance the use of metal spraying to build up shafts of worn armatures without removing the winding is well known. The cost is fractional as against the value of the parts saved, even after consideration of the costs of preparation and of final machining. These usually are much more than those of metal spraying. The savings due to metal spraying for reclamation have been the subject of some publicity but they cannot well be over-emphasized.

The economics of the process are of interest to the producer or metal-spraying contractor. On this subject there is very little published and it may be well to call attention to some facts.

There may be considerable discussions on the methods of gritblasting especially for site work. Open gritblastng is often inadmissible owing to the spread of abrasive but occasionally it can be carried out with a sharp silica sand which is very much cheaper than any other abrasive and recovery may not be essential. Its use necessitates the site being completely vacated by other operators while the work is going on, but its use if often possible on the underside of bridges, especially over rivers where the falling sand cannot do harm. Sand cannot normally be used in dry docks because of the filling of the dock and damage to machinery. It is not permissible over railway tracks because fine sand will fill the ballast on the tracks and prevent drainage and also it is likely to effect signals and points. Recently much blasting has been carried out with fused bauxite or with certain types of crushed slag obtained from smelting processes. If there is any chance of some recovery as when operating in the tanks of ships this is a cheap abrasive to use and it has good cutting qualities (Table V). If the position is such that steel grit must be used, the economics become very unattractive unless full recovery can be made. It is for this reason and to prevent abrasive flying everywhere that the "Vacu-Blast" plant is now being used. Unfortunately, although it is effective it is very slow. The lack of speed is not an inherent defect of the method but is due to the heaviness of the exhausting equipment at the working head. If this can be supported in any way to take the strain from the operator much faster working can be achieved and the process is extremely useful. It is not usually possible in practice to obtain greater average speeds than 0.8 sq. metres per hour from this apparatus, under the conditions existing on many sites. Nevertheless, in some cases this may be economical when set against those necessitated by collection and cleaning up after open blasting.

Table V.

Comparison of costs of abrasives suitable for blasting for metal spraying in Great Britain (approximate only) per metric ton.

silica sand	£6 - £6.
crushed slag	£6.5 - £7
aluminous abrasive	£36 - £38
angular steel grit	£29 - £31
*steel shot	£100 - £105

* an abrasive introduced for centrifugal airless blasters and being round not suitable for final blasting for metal spraying.

In this connexion it is interesting to consider the case of gritblasting inside tankers. If this work is carried out with open blast jets using crushed slag, if the abrasive is to be swept up and returned to the chamber of the machine by bucket it may be necessary to have one labourer to each blaster, perhaps necessitating an increase of 40 per cent. on the total wages bill. If the material is picked up by suction and is returned automatically a great saving is made but the apparatus required is of high capital cost. It is also subject to bad handling and wear so that depreciation must probably be allowed at about 15 per cent. It is apparent that the area of work must be consider-

able in order to make such methods attractive. Nevertheless, the areas requiring cleaning have been so large that expenditure of £20,000 on plant have been considered justifiable in American practice.

When metal spraying and blasting can be carried out in a works and the volume of one type of material is sufficient to warrant it, grit blasting by the airless or centrifugal type of machines is the most economical. The installation costs are high but the machines are capable of very high outputs. Some idea of the economics involved can be obtained from Table VI. Where mechanized cleaning of this type is possible it can often be followed by mechanized metal spraying. The figures in Table II are based on a plant of this kind.

Table VI.

Costs of Airless Blasting.

The installation costs are heavy and maintenance is high but the output is very large and if the machines are worked continuously the process is very economical. The costs vary with the type of work, some figures as a guide are/on steel sheets, both sides cleaned in one pass.

10 sq. metres	=	£0.22
Steel plates 10 sq. metres	=	£0.80
Sectional Materials 10 sq. metres	=	£1.00
Castings contaminated with sand	=	£3.5 per metric ton.

These figures are only for guidance and must vary with circumstances. As an example of their make up the following approximations can be given.

Cost of plant.	£10,000 annual depreciation	£1,000
	Sinking fund interest say	£ 220
	Cost of spares in one year	£1,200
	Yearly charge	£2,420

Year = 272 days of 8½ hours. Hourly charge approx £1.
Area treated 2000 sq. metres.

Wages, loading and unloading	£15
Maintenance Wages	£15
Angular grit	£65
Electricity	£19
Add hourly charge; 57 hours	£57
	£171
Cost per 10 sq. metres	£0.855

Table VII.

Possibility of uneconomical working by increasing hourly output. In these cases of spraying work with perforations and edges.

Spray 10 kg. per hour	30 kg. per hour.
less 40% 4 kg. less 55%	16.6 kg. per hour.
cost of zinc lost. £0.56	2.31
ratio of area covered for given thickness	2.25

If wages per hour taken as £0.275 then wages saved will be £0.34 but metal lost increases to £1.05 and if half is recovered it is still likely to be more profitable to use the smaller pistol.

For ordinary cleaning work and preparation for metal spraying in the works the compressed-air method still is most important. The most modern plants have automatic returns for the abrasive so that no manual effort is required in refilling the machines, the circulation of the abrasive being continuous. Compared with the older method of the blaster or a labourer shovelling back the abrasive the saving is considerable. For instance using a medium nozzle on one type of work the average area blasted over 50 days in a room with an automatic return was 44 sq. metres per day as against 29 sq. metres per day in the older type. Furthermore, the work was much more satisfactory as the abrasive is cleaned during the automatic return.

Another problem is that of the type of metal spraying pistol to be used, without reference to any particular make. The consideration is whether a pistol using small diameter wires giving limited output or small powder pistols, motorized modern pistols using 5-mm. diameter wire or large powder pistols, should be used. This is very often a difficult matter to decide. For instance, in the spraying of steel window frames when, even if the frames are stacked together, there is a good deal of loss, it may well be that the use of a slow running powder or a wire pistol with only 2-mm. zinc wire will be less costly than using the very large tools which are now common (Table VII).

In the special case of the spraying of zinc the use of heavy-duty pistols must mean the projection of very large quantities of dust in a given time and it may well be that if such pistols are used there is no alternative but to increase the ventilation plant beyond the economic limit, owing to the heavy capital cost. With aluminium which is used to a great extent there is more advantage in using the heavy-duty pistols but it is desirable to increase the nominal thickness of deposit by 0.025 mm. in order to overcome the increased porosity which is usual with coatings produced at high speeds. Despite the higher cost of aluminium metal and its slower speed through the pistol, its lower-density and lower-loss figure balances the disadvantage and there is not much difference in the final costs between zinc and aluminium.

In the case of building-up the use of heavy-duty pistols is completely justified always providing that the area to be covered is large enough and the use of heavy-duty nozzles is usually essential. The plant can be mechanized. It is not always easy to discover when mechanization should be employed as the capital cost has to be taken against the saving achieved. When work is repetitive, mechanization is always to be preferred because it gives an even uniform coating and close inspection is not so necessary. Some mechanized plants in Great Britain have given very satisfactory cost results but

it is necessary to make the machines as simple as possible.

In the case of automatic plants it is always possible to see further methods of mechanization but care has to be taken that any complications are likely to stand up to the vigorous service conditions. In metal spraying there is always dust and for this reason pneumatic controls are usually preferable to electronic ones. Automatic lighting devices are usually justified.

One of the problems facing the contracting works management is the decision of the size of grit-blasting and ventilation plant. Whatever machine is decided upon and installed it will be found that the next job will be larger than anticipated. The optimum size of plant is a very important matter. The problem of dust recovery and its economics is especially important with the powder system. The dust produced by a metal spraying gun is not a very saleable article because it is not easily melted or refined and the practice of returning powder to the pistol is not to be recommended technically. The recovery value is not large in relation to initial cost. It is necessary in order to obtain the highest value to segregate one metal from another and in exhausting plants this is not always easy.

Increases in dust formation require at least a proportional increase in fan or ventilating capacity. Usually the air passing from the shop needs to be cleaned either by passage through cyclones or even bag filters. In either case there must be a proportional increase, either in the size of the cyclones or area of the bag surface.

One of the greatest difficulties in contracting metal spraying is that of handling. If the handling is done with overhead cranes special precautions need to be taken to prevent the dust getting into the mechanism and electric motors. The capital cost is large but undoubtedly the method is quick and effective. The other method is to strengthen the floor of the building and use (Table VIII) mobile cranes this gives greater flexibility, as parts can be taken from the stack yard and the work moved around fairly rapidly. No fixed rule can be applied and decisions must be made with reference to local conditions and all that needs to be stressed is the necessity of rapid handling by means of slings which do not damage the finished coating.

It always appears to the author that sufficient attention is not given to the costs of compressed air. In industrial areas where electricity is cheap this may not be a major item although it is often about one sixth of the direct wages bill. The provision of air on sites where mobile compressors are necessitated, driven by petrol or diesel engines is a different problem. (Table IX.)

Table VIII.

Comparison of costs of lifting methods.

Area 30 x 12 metres. 10 metric ton lift.

Mobile Crane.	9-metre jib	£6,500
	Cost of increasing concrete of floor to 25 cm.	400
		£6,900
Gantry Crane.	Self supporting gantry	£2,000
	Foundations for columns	300
	Electric travelling crane	£3,250
	Pick up wires, switches, etc.	200
		£5,750

Cost of running and maintenance of the mobile will be greater but if a stacking yard is available with strengthened floor the unit has more freedom.

Table IX.

Comparative Compressor Costs

Capacity of Compressor in metres per hr. 7 kg. per sq. cms. gauge pressure	Type	Approx. cost	Running cost excluding maintenance £ per hour
8.5	electric drive	including motor switch £1,250	electricity 120 kw.hrs. per £1 0.375
8.5	diesel drive	including engine £2,700	oil £0.03 per litre 0.370
25	electric drive	including motor £4,750	£1.22
50	2-stage compressor electric drive	£9,700	£2.4

It will be noted that with increasing capacity capital costs increase but running costs are smaller. It seems likely that in Metal Spraying use of multiples of smaller units are preferable giving greater flexibility.

Table X.

The approximate relationship between power required to compress air to satisfy varying blast nozzle diameter.

Diameter of nozzles in millimetres / gauge pressure kg. per sq. cm.	6.4	12.7	19	25.4
2.1	(1.14) 3.0	(4.5) 11.7	(10.3) 27	(18.2) 47
4.2	(1.92) 7.6	(7.65) 30.6	(17.2) 68.8	(30.6) 122.4
6.3	(2.7) 14.0	(11.8) 56.5	(24.2) 126	(42.7) 222
8.4	(3.44) 20.6	(13.8) 82.8	(31) 186	(55) 330

Gauge pressure is pressure above the atmosphere.

Figures in brackets are flow of free air at atmospheric pressure and at ordinary room temperature in cubic metres per minute.

The powder figure is in rating of the motor in kilowatts, single stage compression, adiabatic with jacket cooling ignored adding 15% above theoretical values.

It will be seen that the cost of using a 19-mm. diameter nozzle at 6.3 kilogrammes per sq. cm. is approx. 4 times that of a 12.7-mm. nozzle at 4.3 kilogrammes per sq. cm.

(*Continued in page* 70)

A Survey of Progress in the ELECTRODEPOSITION OF PRECIOUS METALS

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(One of a series of lectures, presented under the title of " Recent Developments in Electrolytic Metal Finishing " at the Borough Polytechnic, London, and published by the permission of the Head of the Division of Metal Science).

THE history of the electrodeposition of the precious metals has always been very closely linked to the decorative trades, jewellery, cutlery, etc., and due, most particularly to the high cost of the metals, has for many years been confined to " flash " deposits.

The more recent growth of the electronics industry has, however, stimulated considerable interest in their rather unique properties and has resulted in great technical advances in formulations and practise. Silver has been somewhat of an exception, both regarding its intrinsic value and its technical application ; progress nevertheless was slow and the greatest advances have run parallel to other members of the group—that is over the last ten years.

The increasing use of the precious metals has required more specialized equipment in order to obtain technically consistent and economically good results.

Platinum Plating

To some extent the retardation of progress in platinum plating has been due to the similarity of its properties to those of rhodium, particularly reflectivity and tarnish resistance ; for whereas rhodium was plated from a relatively stable bath, more serious technical difficulties were encountered with platinum. Recently, however, a critical re-examination of the precious metals in the contact field has awakened fresh interest, while specific uses, such as the cathodic protection afforded to titanium and tantalum, has considerably increased its use.

There have been, over the past few decades, only three platinum baths to achieve limited commercial success. The first[1] uses diamino dinitro platinum dissolved in dilute ammonia solution with additions of ammonium nitrate and sodium nitrite. Operated at 95°C., this bath rapidly loses ammonia and as the nitrite ions increase during use, the cathode efficiency gradually falls to zero. Under these conditions the bath is only of value for " flash " deposits, thicker deposits becoming powdery if not frequently scratch brushed.

Variations of this bath using phosphates with the complex, have not led to any marked improvements of performance.

An alkaline bath[2] prepared by dissolving sodium hexahydroxy platinate in caustic soda has been used, but the lifetime is severely limited by its sensitivity to carbonation, and the plate characteristics are not satisfactory in thicknesses greater than 0.0001 in.

An acid bath developed by Atkinson[3] consisted of chlorplatinic acid dissolved in hydrochloric acid, but a high operating temperature of 90°C. plus the great acidity of the bath has precluded its use on all but specific occasions.

Most recently, Hopkin and Wilson[4] have produced bright, smooth deposits up to 0.001 in. thick from a bath based on sulphato-dinitro platinous acid, $H_2Pt(NO_2)_2SO_4$, operated at a pH of <2 and at a temperature of 40°C., a current density of 5 amp. per sq. ft., yields most satisfactory deposits with a hardness of 400 to 450 VPN. Cathode efficiency is approximately 15 per cent.

Palladium Plating

Electrodeposited palladium has not found much use in the decorative and jewellery trades, due to its susceptibility to finger-print staining. It has, however, found certain applications in printed circuitry, particularly where direct deposition on the copper contact is required, and also in the electronic field as a non-tarnishing finish for silver-plated waveguides and other components.

The bath most frequently used in this country[5] is based on tetramino palladium nitrate $Pd(NH_2)_4(NO_3)_2$, together with ammonium nitrate and

* Silvercrown Ltd.

sodium nitrite. Operated at a pH of approximately 7 and in the temperature range 60 to 80°C., current densities of 5-20 amp. per sq. ft. may be employed if adequate agitation is provided. Under these conitions a cathode efficiency of approximately 100 per cent is obtained and the deposit itself, with a hardness of 300 to 400 VPN, is substantially free from the internal stress associated with rhodium deposits. Unfortunately this bath does deteriorate with prolonged use and must then be replaced.

Other baths which are favoured include the strongly acidic palladium chloride/ammonium chloride solution[6] adjusted to a pH of 0.5 to 2.0 by hydrochloric acid. Although by using pure palladium anodes a balanced electrode efficiency of almost 100 per cent is obtained, the acidity of the bath precludes its use on all but the noble metals.

Other solutions based on palladium diamino nitrite[7] and on potassium[8,9] palladium chloride in a potassium chloride/potassium nitrite electrolyte are also used, particularly in the U.S.

It would appear that although the use of palladium is at present limited to certain specific applications, its lower intrinsic value and specific gravity would increase its competition to rhodium and platinum in cases where resistance to attack by nitric acid does not preclude its consideration.

Rhodium Plating

Rhodium has only a comparatively recent history as an electrodeposit, having been first used commercially in the jewellery field about 1930, and industrially only during the last seven or eight years. Rhodium is resistant to acids, alkalis and most corrosive chemicals ; is only superficially oxidized at 800°C. in air and with a hardness 780 to 820 VPN presents an extremely wear-resistant surface of high specular reflectivity. Its electrical conductivity is approximately 40 per cent that of pure copper.

Rhodium finds use in thicknesses varying from 5 millionths to 0.0002 in. on printed circuits, sliding contacts, relays, low-voltage contacts, waveguides, etc. It is usually deposited on either a nickel or silver plated surface, choice depending on electrical requirements. (Fig. 1).

The electrolytes normally used are :

(1) A solution of rhodium phosphate with phosphoric acid.
(2) A solution of rhodium phosphate with sulphuric acid.
(3) A solution of rhodium sulphate with sulphuric acid.

In almost all cases of heavy deposition the third bath appears to be preferred, although the all-phosphate bath is widely used for direct deposition on tin alloys and soft soldered components.

Platinum anodes are used and the deposited rhodium is replaced by adding a syrup of the appropriate salt.

When using the all-sulphate bath, several formulations are available, and choice is usually governed by the thickness and/or physical properties required. The heavier the deposit required, the higher must be the rhodium content of the solution. Agitation increases the cathode efficiency of the process considerably and is always used for heavy deposits. Rhodium hydroxide tends to precipitate from solution at a pH greater than 2.0, and it is necessary to ensure the minimum acid content to prevent this occurring. Excess acid over this quantity is often added to reduce stress in the deposit, and the plating temperature should be maintained between 40 to 60°C. for the same reason.

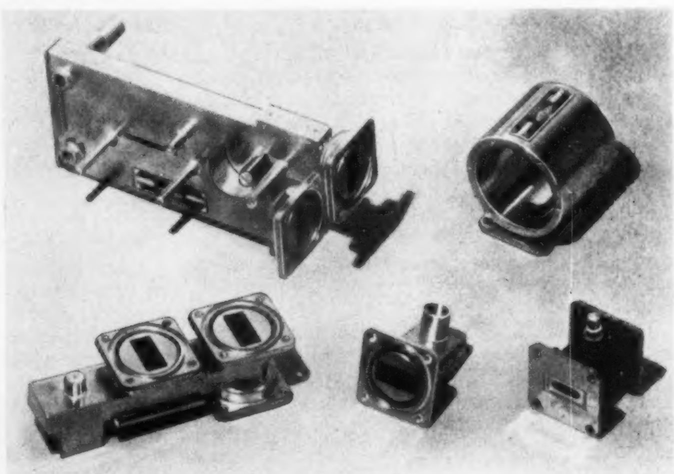


Fig. 1.—Typical gold and rhodium plated components.

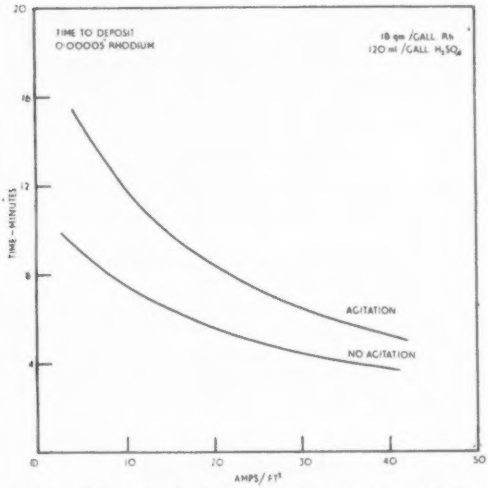


Fig. 2.—Effect of agitation and current density on rhodium sulphate-sulphuric acid plating solution (0.00005 *in. deposit*).

Rhodium solutions are very susceptible to metallic contamination and yield streaked and highly stressed deposits quite unsatisfactory for industrial use. Organic contamination can also prove harmful in practice, and filtration through activated carbon is often practised to counteract this.

In order to obtain maximum adhesion of the deposit to the nickel or silver plated underlay, any surface passivity must be destroyed and the surface preferably etched before entering the rhodium solution. Failure to observe this may cause premature service failure.

Rhodium may be deposited in a barrel from a dilute, all-sulphate bath of the type already described.[10]

The graphs, Figs. 2 and 3 illustrate the effect both of agitation, current density and metal content on the efficiency of the rhodium sulphate/sulphuric acid plating bath ; in this case expressed as a time for deposition of a standard thickness of rhodium.

As previously mentioned, the all-phosphate bath is sometimes preferred for deposition on tin alloys. As with the sulphate bath, the rhodium content must be increased in an identical manner for heavy deposits, and the quantity of acid necessary is normally twice that of the sulphate baths. The working conditions of the solutions are similar, but in general, the sulphate bath produces brighter deposits over a wider range of operating conditions. With baths containing an equivalent amount of rhodium, cathode efficiencies in the sulphate solutions are invariably twice those obtained from the phosphate solution.

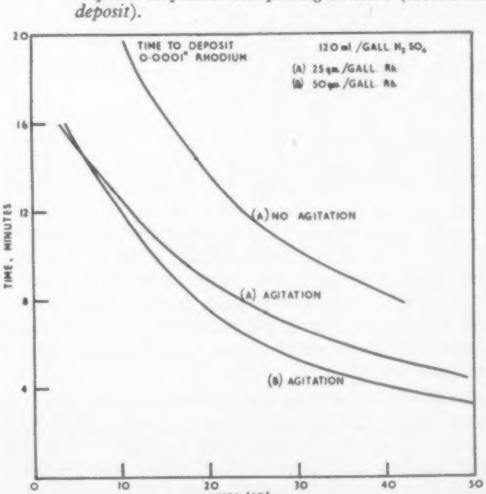
The mixed bath shows some of the advantages and disadvantages of the simple solutions, but is not so widely used.

Silver Plating

Silver plating has been practised for more than one hundred years as a decorative finish, and more so than any other precious metal, by demand, simplicity of deposition and considerably lower cost, has become as familiar to the plater as the base metals. In spite of this, progress has been slow, and even at present, although for technical applications high-speed, bright plating solutions are most frequently used, decorative platers still tend to follow the practices handed down through the years.

Although silver may be deposited from a variety of baths, the electrolyte based on silver potassium cyanide with added free cyanide finds almost exclusive application. Additions of potassium carbonate, potassium hydroxide and potassium nitrate are sometimes made to increase the conductivity of the solution and the present tendency is to use higher metal and higher free cyanide contents, with higher temperatures to increase the limiting current density and hence the speed of plating. Thus, depending on specific requirements the silver content of the bath may be varied between 2 to 16 oz. per gal., the free cyanide between 1 to 16 oz. per gal. and in the temperature range 20 to 60°C. Current densities in the low concentration baths would normally be from 3 to 15 amp. per sq. ft., while with sufficient

Fig. 3.—Effect of agitation and current density on rhodium sulphate-sulphuric acid plating solution (0.0001 *in. deposit*).



agitation, current densities of 50 to 60 amp. per sq. ft. may be achieved with the high speed baths. Under all satisfactory operating conditions the electrode efficiencies are balanced at approximately 100 per cent, but it is essential to avoid wasteful disintegration of the anodes by selecting the correct anode for the job. The anode selected must be of 99.97 per cent purity and in the case of high speed solutions have a very small and even grain structure. There is also some indication that the shape of the anode might be helpful in certain cases in preventing edge decay. Although bagging of anodes is frequently practised, an anode diaphragm, where convenient, is preferred.

As deposited, unless P.R. current is used, silver is a white, matt metal, and particularly in the decorative trade, has been brightened by additions of carbon disulphide, frequently stabilized by Turkey Red Oil.

More recently, ethereal solutions of carbon disulphide have been used and the use of ammonium thiosulphate has also found favour.

For technical applications, however, the fully-bright deposits obtained from several proprietary baths are preferred because of their greater hardness and wear-resistance, their better corrosion and tarnish-resistance and relative freedom from porosity.

One of the most widely used of these solutions[11] uses as a primary brightener a reaction product of carbon disulphide and ketone, together with a wetting agent as a stabilizer and subsidiary brightener. With a silver content of 5 to 6 oz. per gal.. and a free cyanide content of 10 to 16 oz. per gall. current densities of up to 60 amp. per sq. ft. may be employed if the agitation is sufficient and the temperature raised to the upper limit of its 20 to 50°C. range. The deposit obtained from this bath is fully-bright, ductile and has a hardness of 110 VPN. In addition to the qualities mentioned, it has a conductivity of approximately 110 per cent that of pure copper.

Other patented processes use antimony compounds[12] and selenium compounds[13] as brighteners and produce under specified operating conditions, hard and bright deposits. It is, however, believed that the incorporation of these metals in the lattice to some extent lowers the conductivity of the silver.

It is usual with silver plating either to "strike" the base metal in a low silver, high free cyanide bath, prior to actual plating, or, in some cases, use either a mercury quicking solution or a copper undercoat produced from a standard acid copper electrolyte.

Silver may be successfully barrel plated over a wide range of operating conditions and with a wide range of equipment, and both because of this and the lower cost of silver metal, rather less attention is paid to metal distribution curves and conservancy of metal deposited than with other precious metals. It is possible, however, that the wide introduction of savings in gold barrelling will prompt more attention in this direction in the near future.

Gold Plating

There are two main types of solution employed in the decorative and technical deposition of gold. These are :

(a) Gold cyanide electrolytes, alkaline.

(b) Gold cyanide electrolytes, acid.

Gold may also be deposited both from an acid bath based on chlorauric acid, from several complex gold baths and also from the so-called Yellow prussiate baths, based on gold chloride and potassium ferrocyanide.

Decorative Plating

In decorative gold plating it is customary to deposit a " flash " gold finish to an already bright surface ; or alternatively, to plate a thicker gold deposit and polish to a high lustre. For these purposes, the baths most frequently used are based on gold potassium cyanide with added free cyanide. The gold content is normally fairly low at 3 to 6 dwt. per gal. and additions of other metals, such as copper, nickel and silver are made either singly or in combination to adjust the colour or shade of gold from red to yellow-green. This type of bath is normally operated at temperatures of 140 to 160°F. and at current densities between 10 to 50 amp. per sq. ft. The free cyanide content may be maintained between 1 to 2 oz. per gal., and particularly in baths containing copper, is used to control the shade of deposit. Disodium phosphate is frequently added to cyanide gold baths to increase conductivity, counteract, the hardness of water, and is also reputed to give a finer-grained deposit.

Agitation is normally provided both to increase the cathode efficiency and also the permissible current density. Too high a current density causes burning of the deposit when plating 24 c. gold, and otherwise alters the alloy content. Higher efficiencies and increased plating speeds may also be obtained by increasing the gold content of the solution, but this is not a customary refinement, it being more expensive both in capital outlay and running costs and also decreasing the throwing power of the bath.

Although improved results are obtained with ageing of the solution, there is a gradual fall-off in performance when the carbonate content of the bath increases beyond 12 to 14 oz. per gal. and replacement of the solution is often economically advisable at this stage, the gold being recovered.

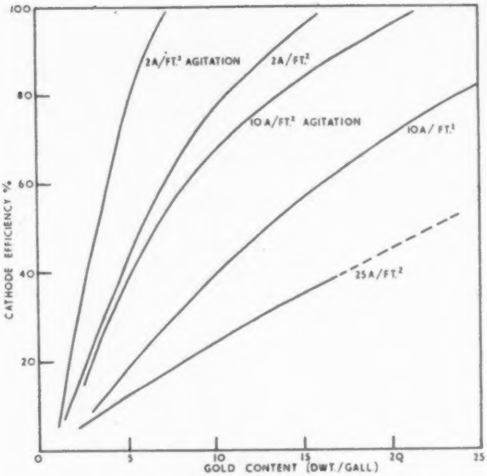


Fig. 4.—Effect of gold concentration on cathode efficiency cyanide electrolyte.

Industrial Plating

Although some technical gold plating has been carried out for many years, it is only in the last decade that this industry has been really developed. Its development has been chiefly due to the growth of the electronic industry. At first the demand was only for pure gold or 24 c. gold, because the electrical conductivity of such deposits was almost as good as silver, without any of the subsequent tarnishing problems. As requirements arose for improved corrosion resistance, heavier and heavier deposits of gold were required. With still further developments, other properties became important, thus :

(1) In the transistor field trace quantities of Gp 3 and Gp V elements were incorporated for use in junction boundaries with semi-conductors.

(2) Trouble was encountered with seizing and galling of gold to gold contacts in connectors and led to the incorporation of nickel into the deposit.

(3) Attack by high temperature, high free cyanide electrolytes on printed circuit resits and base-boards was overcome by use of both mildly acidic electrolytes and room-temperature, low free cyanide baths.

(4) High-temperature applications caused diffusion of copper, silver and nickel undercoats, and resulted in the development of special baths to combat this effect.

24 C Plating

Cyanide electrolytes, alkaline

The gold deposits required are normally considerably thicker than in decorative plating and the electrolytes used contain more gold than those previously discussed.

The gold content is usually maintained at 1 to 1.5 oz. T. per gal., and the free cyanide between 2 to 4 oz. per gal. At temperatures between 130 to 160°F., current densities of 2 to 10 amp. per sq. ft. may be used, and with good agitation, high cathode efficiencies may be obtained, as shown in Fig. 4. P.R. current is often employed for heavy deposits , otherwise some burnishing may be necessary after plating.

Gold cyanides, electrolytes, acid

There has been developed recently a series[14,15] of proprietary gold plating electrolytes based on gold potassium cyanide dissolved in various, complex solutions—the *p*H being adjusted in the range 3.5 to 5.0.

Such electrolytes are normally operated at room-temperature and at current densities in the range 5 to 25 amp. per sq. ft. produce smooth, fully-bright and ductile deposits of 24 C. purity, yet possessing exceptional hardness (110 to 120 VPN) and wear-resistance. The purity and grain structure of the electrodeposits ensures freedom from porosity and increases resistance to corrosion, tarnishing, etc.

One electrolyte in this series has been developed to resist diffusion of underlying metals in high temperature applications; minimum resistance being 5 hours at 400°C. Gold is quite insoluble in this type of solution, either chemically or anodically, so that stainless steel anodes are normally employed, the gold being added as gold potassium cyanide. Current efficiencies increase with increasing *p*H and also with agitation, and are normally between 30 to 70 per cent as shown in Fig. 5.

Excellent results are obtained in barrel plating applications, while the *p*H of the bath makes this type of solution ideal in many cases where conventional, cyanide-based electrolytes have failed. Copper, brass, nickel, silver and certain steels may be plated directly without the normal "strike" required with most gold solutions.

There is no doubt that the use of these slightly acidic electrolytes will expand considerably in the years ahead.

Gold-alloy Deposits

Gp 3 and Gp V elements

The first commercial transistor was sold in 1949, and a new era commenced in alloy gold plating. The hearing-aid industry was the first major user, because their requirements best fitted the first transistors ; low frequency and low power requirements. For use as n-type transistors, with excess electrons, traces of arsenic or antimony were incorporated in the lattice ; while for the electron deficient p-type transistors, gallium or indium

alloys were used. The transistors are actually made by heat-fusing the electroplated alloy with germanium.

Nickel

Incorporation of nickel in the lattice reduces the crystal size and gives less porous deposits. It gives an increased tarnish-resistance and anti-galling surface and also reduces the diffusion of silver through the deposit[16]. Alloys containing 0.1 to 6.0 per cent nickel may be produced ; hardness of the gold practically doubling with each 2 per cent increase in nickel content. Electrical resistance, however, also increases with increased nickel content and care must be exercised in solution control during plating.

Silver

Silver is frequently incorporated into gold deposits to give a more wear-resistant surface. If too much is added, there is a danger of tarnishing and increased contact resistance occurring. The amount is usually between 1 to 3 per cent silver, although on occasions, as much as 8 per cent is used.

Various electrolytes are available which permit these alloys to be deposited at room-temperature from baths based on gold potassium cyanide with added silver cyanide. The free cyanide content of such baths may vary between 0 to 16 oz. per gal.; although the gold content must invariably be 1.5 oz. T. per gal. The silver content of the alloy increases with lowering current density, increasing agitation, and also as the silver content of the bath increases. This type of solution is ideal for barrel plating and in printed circuitry, particularly when the free cyanide is at zero. Deposits are normally in the hardness range 120 to 150 VPN and are bright, ductile and easily reproducible.

Harr and Cafferty[18] also laid down conditions necessary to deposit an alloy containing 8 per cent silver and found that the ratio of gold to silver metal in the electrolyte was the most important factor affecting composition of the deposit. Lowering C.D., as with the room-temperature baths, increased the silver content of the deposit ; while the free cyanide content between 1 to 10 oz. per gal. is relatively unimportant. Temperature was found to affect the physical properties of the deposit and was accordingly maintained over 150°F.

Other elements

Copper, molybdenum and uranium are all quoted as being used for specific purposes as alloying elements in gold plating.

Equipment

The high intrinsic value of the precious metals coupled with their high densities makes strict control of the process imperative. All platers of precious metals deposit to specification and no plater can afford to deposit any more than the minimum quantity of metal necessary to meet his particular specification. On a genuine production basis the only adequate method of ensuring economic specification plating is by maintaining fully automatic control of the plating variables. Whilst the initial cost of installing equipment of this type may be high, it will almost certainly be small by comparison with the value of metal subsequently deposited and will certainly pay for itself in terms of direct saving, consistency of results, etc.

Vat Plating

With the exception of certain silver plating electrolytes, where a traditional lead or glass-lined tank may be preferred, plating vats are usually of stainless steel, earthenware, rubber-lined mild steel or approved plastic material, heated either externally by means of a water jacket, or internally by a suitably sheathed electric immersion heater. The following factors must be carefully and automatically controlled :

Voltage and current density

Each individual tank or unit should be provided with its own individual source of direct current, with suitable ammeter, and volt-meter in circuit (Fig. 6). It may even be necessary to have two ammeters covering more accurately a wider amper-

Fig. 5.—Cathode efficiency of mildly acidic gold plating electrolyte with varying current density and pH. This electrolyte deposits bright, hard, 24c gold.

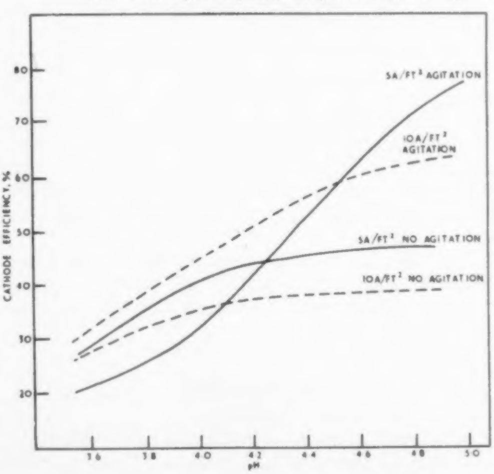


Fig. 6.—Control panel for precious-metal deposition.

age range, with a simple 2-way switch, to choose the one required.

Agitation

In many of the solutions discussed, agitation may exert a profound effect on electrode efficiencies, throwing power and smoothness of the deposit. Whether carried out by means of air agitation, moving or oscillating cathode movement, high speed pumping or a mechanical stirring device, it will be found that for any particular job a specific degree of agitation is required, and it is therefore important before undertaking a production run to establish and maintain the agitation necessary for optimum results.

Time cycle

In processes operating at almost 100 per cent cathode efficiency, and particularly so for "flash" deposits, a process timer fitted with both audible and visual completion signals is essential to prevent wasteful "over plating" and also ensures that at a given current density the thickness of deposit has been achieved. Such a timer might, if required, operate a cut-off mechanism. With processes operating at less than 100 per cent cathode efficiency, and particularly so when the cathode efficiency is variable, the process timer should serve to warn the operator that for a given set of conditions his specification has almost certainly been met, but instead of a cut-off mechanism, it may be preferable to leave a trickle charge flowing until a quick thickness check has satisfied the operator of his results.

Metal concentration

In almost all precious metal plating, in order to minimize drag out losses and to reduce the capital cost of highly expensive solutions, both the volume of solution and its metal content are kept to a minimum. When insoluble anodes are used and heavy deposits demanded, it is essential to maintain the metal content of the solution during plating to within ± 10 per cent of its original value, so that electrode efficiencies, throwing power, etc., are not disturbed. This is most conveniently carried out by means of a suitable ampere hour meter, which can serve to control the metal content of the bath as well as the quantity actually deposited. The most useful meter combines a total amp-hour indicator together with an individual load meter, which may be set at any pre-determined figure and, by operating an alarm device, act as a process timer.

Temperature

Variations in temperature may effect electrode efficiencies and also frequently control the limiting current density of a process. Thermostatic control should be fitted to each individual tank and this also applies to "room temperature" solutions, when some heating may be necessary in extreme climatic conditions.

Analytical control

Many other factors may influence the performance of a solution ; free cyanide content, *p*H, and in alloy plating, the amount of added metals in solution. These factors must be carefully checked, if consistent results are to be achieved.

Barrel Plating

Large quantities of small components which are completely unsuitable for vat plating, must necessarily be plated in barrels, and although in certain cases an oblique, open-topped barrel may be necessary, a horizontally immersed barrel (Fig. 7) is to be preferred for the following reasons:

(a) The cathode area/solution volume relationship is more favourable with immersed barrels and analytical control of the solution is more easily maintained. This is particularly important when the amount of metal to be deposited on a load is more than the quantity contained in the solution, and replenishment during plating is necessitated by the use of insoluble anodes.

(b) Temperature, voltage and current density are more easily maintained and anodic current densities more readily adjusted.

(*Continued in page* 70)

A Survey of Progress in the Electrodeposition of the Precious Metals

(*Continued from page* 69)

(c) For specification plating, there is less scatter of thickness between individual components in the load, and when plating to a minimum specification, this lowers the necessary average thickness, showing large savings in metal consumed.

(d) Greater variations in tumbling can be achieved and if the solution is also pumped through the barrel during plating, better throwing power and more even distribution of plate on individual components may be obtained.

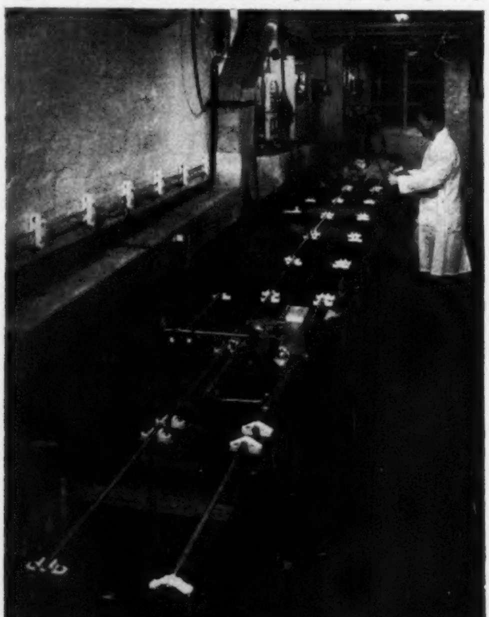
(e) When a process sequence calls for several differing stages, e.g. copper flashing, silver striking, silver plating and gold plating of beryllium-copper contacts, these may be more easily and efficiently carried out in an immersed barrel than by transferring to successive inclined barrels by means of a dipping basket.

(f) Drag-out losses can be more easily controlled and spillage of valuable solutions reduced.

An immersed barrel unit should be treated exactly as a still plating solution and given all the automatic controls mentioned in this connection.

When the small size of the component does necessitate use of an open-topped barrel, great care should be taken in adjusting the size of the load, as it is often particularly difficult to effect a satisfactory compromise between the area of the load governed by the volume of solution, and amperage available and the number of components necessary to ensure good cathodic contact and adequate rumbling.

Fig. 7.—Totally-immersed barrel plant for gold plating.



Filtration

Whether plating in vat or barrel, periodic, or in some cases continuous filtration of the solution may be necessary. As well as removing actual physical particles from solution, filtration through activated carbon may remove any organic contamination. In such cases great care should be taken that a satisfactory grade of activated carbon is being used, both regarding its adsorptive capacity and also its own freedom from metallic contaminants, which, if leached out, may cause even more harm than the organics being removed.

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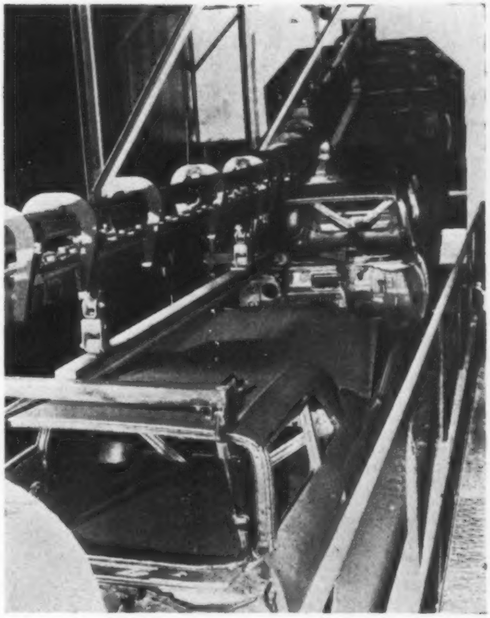
Economic Aspects of Metal Spraying

(*Continued from page* 62)

The modern tendency is to increase nozzle sizes and air pressures for gritblasting but the amount of air flowing through an orifice increases with pressure at logarithmic rate and the area of nozzles increase similarly with diameter. It follows that there must be a point at which rapidity of blasting and labour saving is cancelled out by the costs of producing air and the optimum pressure and nozzle size on site work may not be so large as some appear to think. The amount of air used by the metal-spraying tool is not (Table X) usually large enough to cause concern. In blasting in humid climates it is essential to keep the air as dry as possible and this means installations for cooling to below room temperature and then if possible subsequent reheating. Refrigeration, absorption and chemical means are as a rule too expensive and even the simpler methods increase in cost enormously with increasing rates of flow.

It is hoped that these thoughts on economic considerations may be of help to some in our industry but the problems noted are by no means all that have to be met and exchange of experience is invaluable.

AUTOMATIC SEVEN-STAGE FINISHING LINE FOR CHRYSLER CARS



AN automatic seven-stage finishing line is enabling Chrysler Corporation's City of Commerce plant near Los Angeles to clean, rustproof, prime, and paint automobile bodies at a substantially reduced cost while maintaining a high-quality finish.

It employs both dip and spray coating equipment, instead of paint spray facilities, since the unified body-chassis of 1960 automobiles have hollow areas and boxed-in components which can be more satisfactorily finished when dipped.

The line also uses Chrysler's new rust-proofing system, which is gaining prominence in other automotive plants. Perfected over a period of four years, this system has been proved satisfactory by a quarter-million-mile road test.

A major element of the line is an overhead conveyor, which alternately carries bodies up and down like a roller coaster in order to serve its purpose without taking up floor space between production stations. Its operating speed is such that a body can go through the first of two seven-stage finishing operations in only an hour and 45 minutes.

In the initial sequence of operations, both external and internal body surfaces are respectively and successively immersed in an alkaline cleaner at a temperature of about 175°F., two water rinses with temperatures of about 155°F. and 145°F.,

(*Continued from page* 73)

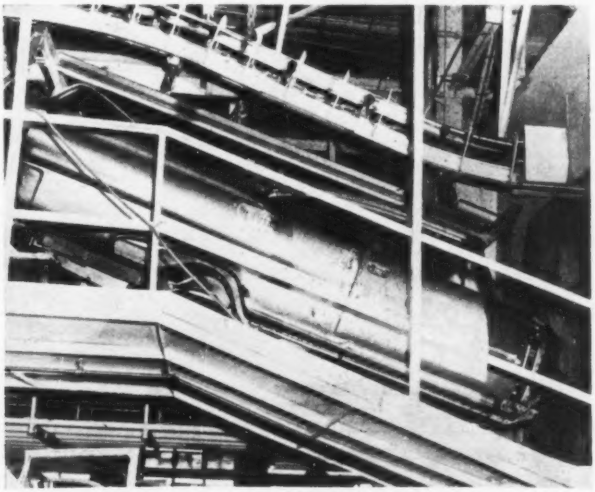
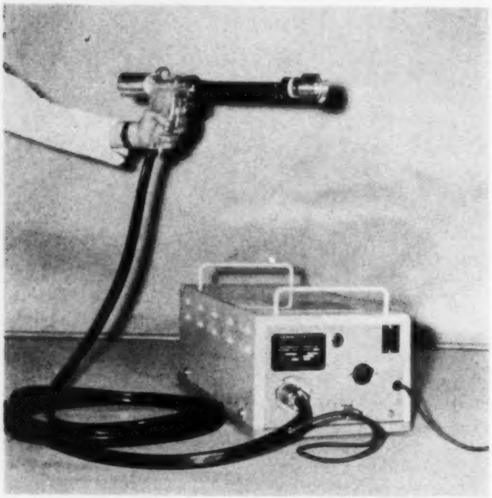


Fig. 1—(above) Bodies entering the slipper dip where below-waist-line surfaces are given a rubber-base coating.

Fig. 2—(left) Body, entering a booth, supported on an overhead conveyor.

ELECTROSTATIC SPRAYING BY HAND



Some Details of the "STATRON" Equipment Now Available in the U.K.

Fig. 1.—General view of electrostatic spray gun and power source.

THE principles of spraying using electrostatic techniques has been understood for many years and many units both large and small have been installed using this principle. SAMES (Société Anonyme de Machines Électrostatiques) have introduced a hand-operated gun using this technique. The Statron, as this unit is called, makes use of an electric field produced by a high-voltage source and with the aid of the centrifugal action of a motor-driven rotating spray head, splits the paint up into fine particles. These particles are positively charged and directed towards and deposited on any earthed object placed within the electric field. The equipment which weighs only 60 lb. is made up of an electrostatic generator, an atomizing gun and a spraying head.

The Generator

The generator has an output of 90,000 volts and is designed to give a constant output current of about 0.2 mA which is independent of the operating voltage. The current can at no time exceed this value. The power consumption is of the order of 100 watts and can be run off the ordinary mains supply. In addition the generator has the advantage of not having a high output capacity.

Spraying Head

The atomizing head is manufactured in either a low-conductivity semi-conducting material or in metal, in a range of sizes 50, 60, 80 or 100 mm. The semi-conducting material greatly reduces the possibility of sparkling and is used in all normal applications, particularly where the paint has a low flash point. The metal head should be used only with paints having a high flash point. The manufacturers recommend the use of a large head for the best atomization but indicate that a smaller head may be of greater advantage where the sprayed object has a distorted shape.

The paint flows to the extreme edge of the head and is atomized by centrifugal force. As the head is maintained at a very high potential, the droplets leave the edge of the head and are split up into fine electrically charged particles. The particles are attracted towards the earthed object to be painted and deposited on its surface. All the particles in this electrified cloud have the same charge and therefore mutually repel each other making the cloud homogeneous. This results in a uniform deposit on the object.

The high voltages available for use with this head give a number of advantages namely better atomization, maximum charge on the particles and better projection. Also, with these higher voltages the influence of the electric field will be greater and it is therefore possible to work much faster.

The Gun

The gun consists purely of a unit to impart the centrifugal force to the head, and a paint inlet

(*Continued in page* 73)

Electrostatic Spraying by Hand

(*Continued from page* 72)

connexion. It has an adjustable output of up to 5 gallons of paint per hour. A choice of feed supply is available with this unit. A simple gravity feeding system from a paint container mounted above the gun can be used or the paint container can be connected to a cylinder of compressed air or to a compressor in the conventional manner. Third, the paint can be fed through a small paint pump.

The outline of the theory of operation shows that in addition to the necessity of having a high electric field the quality of the final result will be better if the solvents used have properties which make them suitable for atomization and spraying. There are many standard, commercially available products which possess the necessary properties but it is recommended for fixed installations to use those which do not lower the flash point of the paint. Paints containing water, however, cannot be used with this unit as they have too high a conductivity but metallized paints can be used provided they do not precipitate out and cause a short circuit in the paint tube. The unit can be used to paint any object which to some extent is a conductor of electricity, for example wood, plaster, cement and of course all metals.

Aerostyle Ltd. have negotiated the sole distribution rights for this equipment in the U.K., and all enquiries should be addressed to them at Broadmead House, 21 Panton Street, London, S.W.1.

Automatic Seven-Stage Finishing Line

(*Continued from page* 71)

a phosphate coating with a temperature of about 130°F., a cold water rinse, a chromic acid conditioner at a temperature of about 145 °F., and a rust-preventive rubber-base coating.

In the second sequence of operations, external surfaces alone are spray finished with two epoxy primer coatings and baked at about 360°F. Then, following a wet sanding operation, they are given two lustrous enamel spray coatings and baked at 250°F.

During the initial sequence, hourly tests are made to determine whether the caustic cleaning bath is of adequate strength, to make sure that rinsing is being properly done and to check the condition of the phosphate bath and chromic acid replenisher systems. The other solutions are tested twice daily.

Phenolpthalein, sulphuric acid, sodium hydroxide, hydrochloric acid, potassium permanganate and similar chemical agents facilitate the above quality control work by bringing about colour changes.

Only the lower body surfaces are dipped during the first seven stages, as the upper surfaces are successfully processed with fixture-mounted spray guns, adequate provision being made to drain excess fluid back into its respective dip tank.

The phosphate and rubber-base coatings are dried as they pass through two gas-fired ovens maintained at temperatures of 380°F. and 225°F.

Between the two seven-stage coating operations, a rubber-base sealer is applied to seams and joints in each body. This sealant expands when the body is later heated, and consequently fills inaccessible areas where it will remain for the life of the car.

Undercoatings, incorporating sound deadening materials, are also applied prior to the second seven-stage operation.

Reduced maintenance and labour requirements make it possible for the new line to turn out a finished body at relatively low cost, and improved coating materials are claimed to make the body's finish more durable.

Most important of the coatings is the rubber-base paint which is applied in the final stage of the initial sequence. It is a non-combustible grey-coloured water-emulsion which becomes impervious to water and most solvents when applied and dried, and it may be used either alone or as a primer for protective purposes. Chrysler claim it is the best rustproofing agent yet developed for metal surfaces.

INSTITUTE OF CORROSION PROPOSED

AT the 2nd annual dinner of the British Association of Corrosion Engineers, Mr. C. L. Wilson suggested that the formation of an Institute of Corrosion would assist in providing a central source of information and a means of classifying workers in the field of corrosion science and research ; he thought that the three bodies concerned, the Corrosion Group led by Dr. T. P. Hoare, the Corrosion Group of the S.C.I. and B.A.C.E. should get together and form a body to correlate work and disseminate information. Dr. Hoare who is head of the Department of Metallurgy at the Cambridge University, also spoke at the dinner, as well as Mr. H. M. Powell, chairman of B.A.C.E., and Mr. Morris T. Shaw, chief civil and structural engineer, War Office. The guests included Sir George McNaughton, vice-president of the Institution of Civil Engineers, Mr. W. H. Driscoll, chief engineer of the Pipeline Division of the Esso Petroleum Co., Mr. Bryan Donking, vice-president of the Institution of Electrical Engineers, Dr. J. E. Garside of the Borough Polytechnic and Mr. A. A. B. Harvey, president of the Institute of Metal Finishing.

FINISHING NEWS REVIEW

NORTH WALES VENUE FOR I.M.F. CONFERENCE

Full Programme of Technical Sessions and Social Events

THE scenic beauties of North Wales will provide the setting for the Twelfth Annual Conference of the Institute of Metal Finishing, which is to be held in May in Llandudno. This choice of venue should provide a considerable attraction for members and visitors from home and overseas to participate in the Conference which, as in past years, will provide a unique opportunity for informal contacts and discussions.

In addition to the main function of the Conference, *viz.:* the presentation and discussion of technical papers, there will be a number of planned evening social functions, including a Conference dinner and dance, a visit to a works and a special programme for the ladies. Full details of the programme will be published in a subsequent issue of this Journal.

As in past years, a full report of the Conference including the papers presented and the ensuing discussions will be featured in future issues of this Journal. All communications regarding the Conference should be addressed to the Conference Secretary, Institute of Metal Finishing, 32, Great Ormond Street, London, W.C.1.

Infra-Red Drying of Enamelware

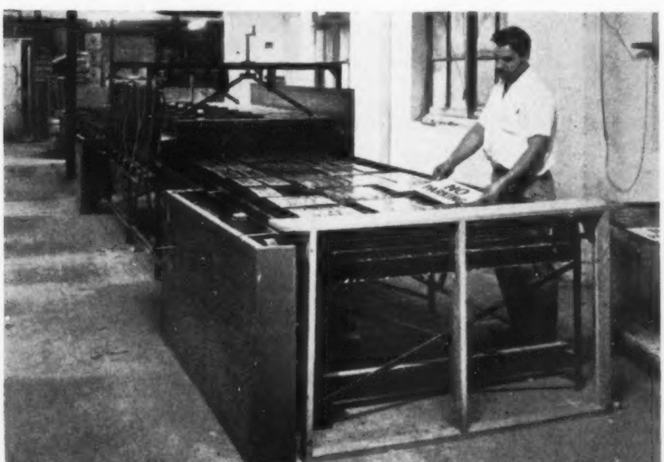
THE firm of James Bruton & Sons Ltd., Palmers Green, London, are using a Vokes infra-red conveyorized drying tunnel for the purpose of pre-drying vitreous enamelware, before firing. The company, in fact, are enamel sign makers and general vitreous enamellers.

The equipment consists of a conveyor, part of its length passing under a series of eight infra-red drying units. It is used to dry both flat and box-shaped articles.

The unit has several advantages for this kind of work. Prominent among them is flexibility, since the infra-red units permit the temperature to be readily controlled within the design limits. The unit is clean to use and portable and can be moved, if necessary, to another part of the factory without difficulty.

The drying tunnel was made specially for this application by George Vokes (Infra Red) Ltd. Its overall length is 40 ft. consisting of a loading zone of 20 ft., a heat zone of 10 ft. and an off-load zone of 10 ft. The conveyor width is 4 ft. Speed can be varied between 2 ft. and 6 ft. per minute. The height of the heat zone above the conveyor can be varied (by handwheel) between 6 in. and 18 in. The maximum current load is 40 kW.

The term infra-red relates to radiant heat applied at the most efficient wavelength, thereby ensuring maximum penetration. In Vokes Infra-Red units, the heat radiated is focused on the work by means of carefully-designed reflectors and practically no heat is lost. In some cases drying times can be reduced from several hours to a few minutes, and often to seconds. Heat is supplied by projector units containing elements constructed of unbreakable Inconel metal tubing of patented oval shape and of almost everlasting life.



On the left is shown the Vokes Infrared conveyorized drying tunnel in use for drying enamelware at the works of James Bruton and Sons Ltd., London.

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PAGINATION

FINISHING NEWS REVIEW

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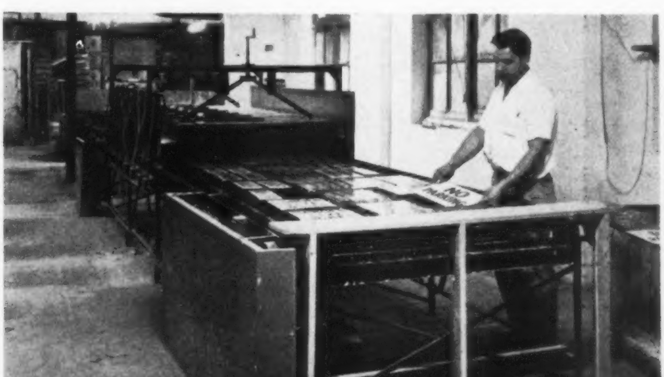
In addition to the main function of the Conference, *viz.:* the presentation and discussion of technical papers, there will be a number of planned evening social functions, including a Conference dinner and dance, a visit to a works and a special programme for the ladies. Full details of the programme will be published in a subsequent issue of this Journal.

As in past years, a full report of the Conference including the papers presented and the ensuing discussions will be featured in future issues of this Journal. All communications regarding the Conference should be addressed to the Conference Secretary, Institute of Metal Finishing, 32, Great Ormond Street, London, W.C.1.



Infra-Red Drying of Enamelware

THE firm of James Bruton & Sons Ltd., Palmers Green, London, are using a Vokes infra-red conveyorized drying tunnel for the purpose of pre-drying vitreous enamelware, before firing. The company, in fact, are enamel sign makers and general vitreous enamellers.

The equipment consists of a conveyor, part of its length passing under a series of eight infra-red drying units. It is used to dry both flat and box-shaped articles.

The unit has several advantages for this kind of work. Prominent among them is flexibility, since the infra-red units permit the temperature to be readily controlled within the design limits. The unit is clean to use and portable and can be moved, if necessary, to another part of the factory without difficulty.

The drying tunnel was made specially for this application by George Vokes (Infra Red) Ltd. Its overall length is 40 ft. consisting of a loading zone of 20 ft., a heat zone of 10 ft. and an off-load zone of 10 ft. The conveyor width is 4 ft. Speed can be varied between 2 ft. and 6 ft. per minute. The height of the heat zone above the conveyor can be varied (by handwheel) between 6 in. and 18 in. The maximum current load is 40 kW.

The term infra-red relates to radiant heat applied at the most efficient wavelength, thereby ensuring maximum penetration. In Vokes Infra-Red units, the heat radiated is focused on the work by means of carefully-designed reflectors and practically no heat is lost. In some cases drying times can be reduced from several hours to a few minutes, and often to seconds. Heat is supplied by projector units containing elements constructed of unbreakable Inconel metal tubing of patented oval shape and of almost everlasting life.

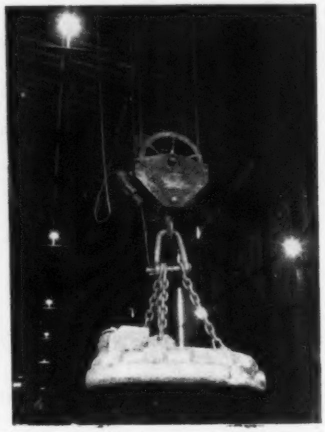
On the left is shown the Vokes Infra-red conveyorized drying tunnel in use for drying enamelware at the works of James Bruton and Sons Ltd., London.

BRITISH–AMERICAN STEEL FINISH COMBINE

AN agreement has recently been concluded between Tool Treatments (Chemicals) Ltd. of West Bromwich and the Chemical Corporation of Massachusetts, U.S.A. whereby the successful chemical black on steel finish produced by Tool Treatments (Chemicals) Ltd. will be marketed under licence in America by the Chemical Corporation and the "Luster-on" products of the Chemical Corporation, who are claimed to be the leading company in America on chromate conversion treatments, will now be marketed in this country by Tool Treatments Ltd.

PLASTIC COVERED CABLES

CABLES clad in a new sheathing material "Niplas," made from a blend of Geon PVC and Hycar nitrile rubber have been standing up to particularly heavy duty in the scrap-metal shed of John Summers and Sons Ltd. The new covering material withstands temperatures up to 85°C., has good mechanical properties and good oil, solvent, fire and abrasion resistance. The cables are produced by Greengate and Irwell Rubber Co. Ltd. and can be made in a variety of bright colours. Geon PVC and Hycar nitrile rubber are made by British Geon Ltd., a company of the Distillers Plastics Group.



BORIC AND BORIC ACID PRICE REDUCTIONS

AS a result of successful resistance by Borax Consolidated Ltd. of Borax House, Carlisle Place, London, S.W.1., the increase in ocean freight charges effective from January 1, has been temporarily reduced from that originally proposed and consequently, Borax Consolidated announce that they will limit the increase in prices to 10/- per ton from February 1. The reduction in the increase in freight charges is only applicable until April 1 when a further revision of prices may be inevitable.

Society of Chemical Industry Award

THE Society of Chemical Industry has awarded their medal for 1961 to Sir Cyril Hinshelwood, O.M., past president of the Royal Society and Nobel Laureate for Chemistry. The medal, which is a senior award of the Society, is presented every two years for conspicuous services to applied chemistry by research, discovery, invention or improvements. Sir Cyril Hinshelwood will receive his medal from the president of the Society, Sir Alexander Fleck, K.B.E., F.R.S., at the annual general meeting of the Society at Oxford in July, 1961.

TUNGSTEN CARBIDE PLATING

A NEW method of applying and bonding a tungsten carbide skin to gauges, arbors, mandrels, etc., has been adopted by E.S.T. (Gauges) Ltd., of Godalming, who claim to have perfected a grinding technique to give a high surface finish with extreme dimensional accuracy. The new range of plated gauges, which will be known as "Tuffest" are said to be considerably cheaper than solid tungsten carbide gauges. The same system can be used to give a skin of nickel-chromium boron or ceramic. In addition to supplying plated gauges E.S.T. (Gauges) Ltd. are prepared to plate customers' components such as shafts, plungers, spindles, slides and other parts which have to withstand heavy wear. The plating can be built up to any required thickness and a perfect bond with the parent metal is obtained, making it extremely useful for salvage operations on damaged or undersized parts, without the risk of flaking.

INDUSTRIAL FINISHES CONVENTION

RAPID progress is being made in finalizing the programme of technical papers which will be delivered before delegates at the First International Industrial Finishes Convention in London. The convention is being planned to run simultaneously with the First International Industrial Finishes Exhibition at Earls Court, London, from May 8 to 11, 1961, as a centre of discussion covering finishing progress in all branches of industry. The titles of papers to be read include — "Paint Finishing Methods and Plant," "Automatic Polishing," "Recent Advances in Organic Finishes," "Developments in Aluminium Finishes," "Water Soluble Resin Finishes," "Advances in Nickel Plating." "Chromium Plating to British Standards No. 1224 ; 59", "High Temperature Paint Curing Techniques," "The Airless Spray Technique," "Titanium for Industrial Finishing Processes," "Problems of Dust in Finishing," "Vitreous Enamel Developments," "Aspects of the Coating of Strip," "Hot Dip Galvanizing," and "Metal and Plastic Coatings." There will also be sessions of technical films which will be of great interest to users of finishes in industry.

The registration of delegates to the convention has now commenced. All delegates will receive a free catalogue and admission to the exhibition as well as the right to be present at all convention sittings and to take part in the discussion on individual papers. The registration fee is one guinea (£1.1.0) or three guineas (£3.3.0) for those wishing to have printed copies of the papers. The convention is being organized by Scientific Surveys Ltd., 97 Old Brompton Road, London, S.W.7 (telephone KNIghtsbridge 9360) who are also organizing the exhibition, 90 per cent. of the display space of which has already been sold.

CHANGES OF ADDRESS

THE London Office of Corrosion Ltd., Warsash Road, Warsash, Southampton, manufacturers of special coatings and treatments for metals has been closed and all technical and service matters are now concentrated at Warsash.

THE sales department of G. A. Harvey and Co. (London) Ltd. now operates from Villiers House, Strand, London, W.C.2, telephone number Whitehall 9931/7. The publicity department remains, however, at Woolwich Road, London, S.E.7.,

TECHNICAL *and* INDUSTRIAL APPOINTMENTS

Following the death of Sir Cecil Weir, chairman of **International Computators and Tabulators Ltd.,** Mr. H. V. Stammers has been appointed acting chairman, Mr. C. Mead, deputy chairman and Mr. J. Bull, managing director.

* * *

Mr. Laurence J. Ford, previously chief development engineer of **Stanley Works (G.B.) Ltd.,** has been appointed chief engineer to bring his title into line with the wider responsibilities which he has carried for some time.

Mr. L. J. Ford

* * *

To cope with expanding business, **Wild-Barfield Electric Furnaces Ltd.** of Watford, Herts., have appointed Mr. W. R. Brew as executive manager (engineering), Mr. F. L. Gladwin as executive manager (commercial), Mr. O. V. Metcalfe as executive manager (production) and Mr. R. C. Ray as sales manager.

* * *

Mr. F. E. Stanley, formerly deputy home sales manager (industrial), has been made commercial manager of **Blundell, Spence and Co. Ltd.**; Mr. I. L. Cameron has been appointed area sales manager (decorative), Scottish sales area, in addition to his appointment as area sales manager (decorative), Northern sales area; the following depot managers have also been appointed—Mr. T. C. Bowden (London), Mr. H. Hickman (Hull), Mr. J. Nunn (Liverpool), Mrs. N. White (Newcastle).

* * *

Mr. R. L. Bonafont, A.M.I.C.E., A.M.Soc. I.C. (France), B.Sc. (Eng.) has been appointed development engineer, responsible to Mr. J. Grant, development manager of the **Ruberoid Co. Ltd.,** and Mr. C. A. L. Scott, B.Sc. (Mech. Eng.) joins the company as assistant to the general works manager, Mr. W. M. Parsons.

* * *

Mr. Peder Field has been appointed conveyor sales engineer for the **Hanson-Van Winkle-Munning Co.** and will be based at the company's headquarters at Matawan, New Jersey. He will be responsible for sales engineering of H-VW-M automatic and related metal-finishing processing equipment.

The district office of **Evershed and Vignoles Ltd.** at 14, Yarm Lane, Stockton-on-Tees, (telephone Stockton 64288) is now under the supervision of Mr. D. Watson and covers the area of Northumberland, Durham, and the Cleveland District of Yorkshire.

* * *

The **Electrical Research Association** have appointed Mr. L. Gosland as deputy director and Mr. C. G. Garton and Mr. E. W. Golding as assistant directors. Dr. R. H. Golde, D.Sc., M.I.E.E. has been appointed head of the Surges and Transformer Department with Mr. M. Waters, B.Sc., M.I.E.E., as deputy head.

* * *

Mr. Peter A. Gill has been appointed general manager of the **Pfizer Chemical Sales Division** in the United Kingdom. Before this appointment he was concerned with the commercial aspects of Pfizer business in international markets. Mr. John Villeneuve, previously Kemball Bishop Technical Service Manager, has been appointed sales manager responsible to Mr. Gill for both chemical sales and technical service.

* * *

British Titan Products Co. Ltd. announce that Dr. P. G. McCarthy has been appointed a director of the company.

OWING to unforeseen delays, Blundell, Spence and Co. Ltd. regret that the introduction of the new 2½-gal. magnum size of Pammastic, and Blundell's Wood and Metal Primer has been postponed until March 1—not February 1—as was announced at the recent Sales Conference.

PRICE REDUCTIONS

LANCASHIRE Dynamo Electronic Products Ltd., Rugeley, Staffs., announce that an immediate price reduction is being made on their Series SME.2 "Smoke Alarm and Densitometer" equipment. The equipment is designed to monitor the density of smoke emitted from chimneys as a protection against the infringement of the Clean Air Act. The Series SME.2 equipment was the first of its type to be awarded the British Standard Institutions "Kite-Mark" certifying full compliance with B.S.S.2740 and 2811, and deliveries of basic installations can be made from stock.

ADDITIONAL PREMISES FOR ROTOTHERM

ADDITIONAL factory premises in Wimbledon, S.W., have been acquired by the British Rototherm Co. Ltd., Merton Abbey, London, S.W.19, the scientific instrument makers. The Wimbledon works, which are in the course of being equipped with the most modern plant, will accommodate a machine shop, dial thermometer production unit and bulk stores.

Metal Finishers Expand

THE Pyrene Co. Ltd. has acquired the business of Perfichrome Ltd., electro-platers, of Brownhills, Staffordshire.

For some years the production capacity of this Midlands firm has been used exclusively by The Pyrene Co. Ltd. as sub-contractors in the manufacture of motor-car bumpers. This business will be operated as a separate division of the Pyrene company, and will be known as the Perfichrome Division.

S.C.I. CORROSION GROUP ESSAY COMPETITION

THE closing date for the receipt of entries for the Society of Chemical Corrosion Group Essay Competition is March 31, 1961, and entries should be addressed to the Society of Chemical Industry at 14 Belgrave Square, London, S.W.1. The competition was established by the Society in 1955 and is designed to encourage those who are still in the early stages of their career to take an interest in corrosion science and express their ideas in writing; the age limit is 30 years and not more than 4,000 words are suggested.

Trade and Technical Publications

G. and R. Gilbert (Industrial) Ltd., Hackbridge Road, Hackbridge, Wallington, Surrey, have recently revised their literature dealing with equipment for the metal finishing trades and industry in general.

* * *

" News Sheet No. 15 " issued by W. Canning and Co. Ltd., Great Hampton Street, Birmingham, 18, describes Canning Nickel Solution 296 which has been developed specially to give a deposit combining excellent corrosion resistance with maximum levelling.

* * *

" Piped Heat," No. 1, is the first issue of a news sheet by the North Western Gas Board intended for circulation among industrialists and heads of large businesses in the North West and among others has articles on new metal-finishing processes by gas and gas-radiant heating.

* * *

The new " Ultrasonoscope " catalogue produced by the Ultrasonoscope Co. (London) Ltd., Sudbourne Road, Brixton Hill, London, S.W.2 sets out the range of equipment available and is also useful as a reference book for the newcomer to the field of non-destructive testing.

* * *

The Plasinter Co. Ltd., Progress Works, Holyhead Road, Wednesbury, Staffs., have issued a new catalogue covering the range of plastic finishes produced by them and the methods of application.

* * *

G. A. Harvey and Co. Ltd., Greenwich Metal Works, London, S.E.7, have issued a booklet " The Harvey Team " which describes the activities of the company, the products and personalities of the management and sales staff.

* * *

" This is TI today " published by Tube Investments Ltd. lists the main constituent companies and their products.

* * *

An article describing the use of plates of Monel nickel-copper alloy in the construction of the 4 ft. wind tunnel recently opened at the Wharton works of the English Electric Aviation Ltd. is featured in " Wiggin Nickel Alloys " No. 59, issued by Henry Wiggin and Co. Ltd., Thames House, Millbank, London, S.W.1. Also included is an article on the value of specifications in electroplating and another on the properties of Nimocast EPE10, a new heat-resisting nickel-chromium alloy for castings.

* * *

The Hanson-Van Winkle-Munning Co. of Church Street, Matawan, N.J., have issued a 24-page bulletin giving a brief description of eighteen H-VW-M electroplating processes. They have also produced a 3 x 5 in. disc calculator for determining the surface speed of both buffing and polishing wheels.

The Company also offers a 16-page booklet describing their nickel-sulfamate process for metal resizing, electroplating, electroforming and other functional uses.

* * *

The British Aluminium Co. Ltd. have issued a well-illustrated booklet " Decorative Super Purity Aluminium " describing the properties and applications of this high purity metal.

* * *

George Kent Ltd. of Luton, Beds., have published a 52-page booklet, " A History of Flow Measurement by Pressure Difference Devices," price 10 shillings.

* * *

" Tin and its Uses," 1960, No. 50, the quarterly journal of the Tin Research Institute, Fraser Road, Greenford, Middlesex, contains, *inter alia*, an article by S. C. Britton and K. Bright on " Resistance of Tinplate to Rust and Corrosion."

* * *

The Mond Nickel Co. Ltd., of Thames House, Millbank, London, S.W.1, have issued a revised version of " Confidence in Plating," which was reviewed last year. The object of the booklet is to promote confidence in chromium plating, provided it conforms to the British Standard for nickel/chromium plate. The number of interested concerns who have adopted the Mond labelling scheme is constantly increasing.

Publications Received

" List of Products," 19 pp. issued by the General Chemicals Department of Albright and Wilson (Mfg.) Ltd., 1 Knightsbridge Green, London, S.W.1.

Inco-Mond Magazine, No. 16, by the Mond Nickel Co. Ltd., Thames House, Millbank, London S.W.1.

* * *

" The Cellon Bulletin," No. 21, January, 1961, by Cellon Ltd., Kingston-upon-Thames, Surrey.

* * *

" The Nickel Bulletin," a monthly review of abstracts of recent literature, by The Mond Nickel Co. Ltd., Thames House, Millbank, London, S.W.1.

* * *

" The Canning Quarterly News " by W. Canning and Co. Ltd., Birmingham, 18.

* * *

" Wrought Zirconium " by Imperial Chemical Industries Ltd., Central Publicity Department, Millbank, London, S.W.1.

NEW COMPANIES

C. P. Baker, 59 Coleshill Road, Marston Green, nr. Birmingham. November 10. £2,000. To carry on the business of polishers, grinders, chrome and general platers. Clifford P. Baker and Julia P. Baker.

Metnor, Warkworth Street Works, Lemington-on-Tyne, Northumberland. November 21, £1,000. To carry on bus. of metal sprayers, cleanesr, finishers. Robert W. Stirling, John R. Rankin.

Polymer Fabrications. November 28. £1,000. To carry on the bus. of manufacturers of plant, equipment and goods used for electro-chemical plating and processing, etc. Gordon H. Cashmore, 26 High Lea, Yeovil, Somerset, John G. Trott, 23 Park Gardens, Yeovil, Somerset, Brian Sims and John P. Wilkinson.

Metapic, 5 Hounsfield Road, Sheffield, 3. December 8. £1,000. To carry on the business of galvanizing, cleaning, pickling and other treatment of metals, etc. Dirs. to be appointed.

Anglo-South African Diamond Polishing Works, 17 Compton Avenue, Brighton. December 8.. £1,000. Colin J. Meyerowitz.

Materials and Methods, 24 St. Mary Axe, E.C.3. December 8. £2,000. To carry on the bus. of mnfrs. and processors of metal and industrial and other materials, etc. George Hobman, Philip S. Attenborough, Oliver Smalley, Eric M. Currie and Edward W. Hardin .

INTERNATIONAL CONFERENCE ON MATERIALS HANDLING

THE second international conference organized by the Institute of Materials Handling is to take place in Southport from May 10 to 12 and will provide a forum for the exchange of knowledge and experience and the opportunity to discuss new methods and trends for the future. It is anticipated that delegates will mostly arrive in the evening of May 9 and although the morning of May 10 will consist of a full programme of visits, the formal opening will be delayed until the afternoon to accommodate those delegates unable to travel before Wednesday morning, after which the first plenary session will commence. A civic reception in the evening will precede a banquet incorporating the 8th annual dinner of the Institute. The morning of the second day will be devoted to works visits followed by discussions, and a film entertainment in the evening. The final day will be devoted to further discussions on standardization, and the conference will close in the afternoon. Further information may be obtained from the Institute of Materials Handling, 32 Watling Street, London, E.C.4.

THREE-DAY COURSES IN OIL-FIRING

THREE-DAY courses on fuel oil-firing are to be held at N.I.F.E.S. Office, Ailsea House, Kings Road, Reading, during March, May, June, September, November and December 1961. The courses are designed to meet the needs of industrial plant engineers, heating engineers and supervisory staff responsible for oil-fired boiler plant. The fee for the course, exclusive of hotel accommodation, will be six guineas. Application forms and a course syllabus may be obtained from the National Industrial Fuel Efficiency Service, 71, Grosvenor Street, London, W.1.

NEW COMPANY TO REPRESENT BRITISH STEEL IN AMERICA

THE Firth Cleveland Group has formed a new company named Firth Cleveland Steels Incorporated, with offices at 230 Park Avenue, New York 17, New York, to act as selling agents in the United States for all companies in the Steels Division of Firth Cleveland ; the president is Mr. Charles W. Hayward, chairman of Firth Cleveland Ltd. and Mr. Tonking of Firth Cleveland Steel Ltd., is managing director and vice-president. The products to be handled include hot and cold rolled, mild, medium and high carbon and stainless qualities of steel strip, hardened and tempered steel strip, wire rod, wire and wire products, steel reinforcement and mesh and hollow bored steel bars.

CROXSON MEMORIAL LECTURE 1961

THE Society of Non-Destructive Examination announces that the first Croxson Memorial Lecture, in commemoration of the late Mr. Charles Croxson, founder chairman of the Society, will be presented on Friday, February 17, 1961, at 6.15 p.m., in the Caxton Hall, Westminster, by Dr. L. Mullins, Ph.D., F.R.P.S., A.I.M., F.Inst.P., on : " The Evolution of Non-Destructive Testing."

Admission to the lecture will be by ticket only.

Applications for tickets—not more than two per applicant—and for further details of the lecture, should be addressed to the honorary secretary of the Society, Mr. D. T. Carter, E.S.A.B. Ltd., Gillingham, Kent.

ULTRASONIC PLANT FOR GOLD PLATING

ULTRASONIC generator and transducer equipment is used by IDM Electronics Ltd. in the production of gold-plated commutators and slip rings by a process carried out under licence from the Electro Tech Corporation in the U.S.A., and consists essentially of encapsulating lead wires in a cylinder of plastic which is cured and then machine grooved. One wire is locally exposed in each groove, all of which are then filled by a gold plating process and machined and polished to a surface finish of four micro-inches. Slip rings and commutators produced by this process are claimed to have considerable advantages over those produced by other techniques, having great mechanical strength, excellent wearing properties and are little affected by wide changes in temperature and humidity. The plating operation is very complex and it is necessary to exercise great care to ensure homogencity especially when gold thicknesses above 0.015 inches are used.

BRITISH CONTROLLING INTERESTS IN SWEDEN

JOHNSON, Matthey and Co., Ltd. have acquired a controlling interest in the Swedish precious metal company A/B Gösta Nyström of Stockholm. Mr. Gösta Nyström, who founded the business in 1917, has retired and a new board has been appointed consisting of four Swedish and two British directors, with Mr. Ove Trulsson as Chairman.

A/B Gösta Nyström supply precious metal products for all industrial purposes as well as for jewellery, silversmithing and dental requirementa. Since 1932 they have acted as agents in Sweden for some of the products of Johnson Matthey.

The company will in future be known as A/B Nyström and Matthey.

NEW BRAZILIAN WATER CONDITIONING COMPANY

A NEW company, Pfaudler Permutit Beneficiamento De Fluidas, LTDA, has been formed in San Paulo, Brazil, as part of the International Division of Pfaudler Permutit Inc., Rochester, New York ; it will come under the direction of Dr. Ernesto E. E. Geiger and will be primarily occupied with engineering, subcontracting and importing water conditioning plant, but will also investigate the question of establishing facilities for manufacturing plastic and/or glass lined vessels. The sale of Pfaudler and Permutit products in Brazil will continue to be the responsibility of Parson, Crosland and Cia LTDA which has handled sales for both divisions for many years.

COURSES IN TECHNIQUE IN PHYSICS

A COURSE in " Experimental Techniques in Physics " by J. A. Pryde, B.Sc., Ph.D. commenced on January 12 at the Sir John Cass College, Jewry Street, Aldgate, London, E.C.3., covering a period of 12 weeks duration and consisting of five lectures followed by five periods of practical work. The lectures of the syllabus are " High Vacuum Systems," " Reflecting and Semi-Reflecting Films," " Elementary Glass Working," " Etching and Electro-polishing of Metals " and " Furnaces."

FORTHCOMING MEETINGS

February 24

Institute of Metal Finishing (Sheffield and North-East Branch). "Chelating Agents in Metal Treatment" by J. K. Aiken, at the Grand Hotel, Sheffield. 7.0 p.m.

February 28

Institute of Metal Finishing (South-West Branch). "Principles of Barrel Finishing" by W. Parry, at the Assize Courts Hotel, Bristol. 7.30 p.m.

March 6

Institute of Metal Finishing (North-West Branch). "Chromate Treatment of Metals" at the Engineers' Club, Albert Square, Manchester. 7.30 p.m.

March 7

Institute of Metal Finishing (Midland Branch). "The Testing of Electrodeposits for Thickness and Corrosion Resistance" by J. Edwards, at the James Watt Memorial Institute, Great Charles Street, Birmingham, 3. 6.30 p.m.

Institute of Vitreous Enamellers (Scottish Section). "Enamelling Cast Iron" by G. Keep, at the Plough Hotel, Stenhousemuir. 7.15 p.m.

March 8

Institute of Vitreous Enamellers (Southern Section). Annual General Meeting, "Open Forum. Application of Cover Coat Enamels including Sheet and Cast," at the Constitutional Club, Northumberland Avenue, London, W.C.2. 7.15 p.m.

Society of Chemical Industry (Corrosion Group). Works visit to The Cleveland Bridge and Engineering Co. Ltd., Darlington. 2.30 p.m. "Metal Spraying for the Protection of Bridge Structures" by J. D. Thompson, at the Technical College, Gladstone Street, Darlington. 8.0 p.m.

Institute of Metal Finishing (Organic Finishing Group). "Automatic Paint Finishing of Refrigerators" by B. Jeffery, at the British Institute of Management, Management House, 80, Fetter Lane, London, E.C.4. 6.30 p.m.

March 20

Institute of Metal Finishing (London Branch). "Zinc Plating from the Pyrophosphate Bath" by U. F. Marx and P. Dovey, at the Northampton College of Technology, St. John Street, London, E.C.1. 6.15 p.m.

March 21

Institute of Metal Finishing (South-West Branch). "Rectifiers in the Metal Finishing Industry" by D. Ashby, at the Royal Hotel, Bristol, 7.30 p.m., following afternoon visit to Westinghouse at Bristol.

March 24

Institute of Metal Finishing (Sheffield and North-East Branch). "Duplex Nickel and Crack-Free Chromium for Improved Corrosion Resistance" by T. E. Such, at the Grand Hotel, Sheffield, 7.0 p.m.

March 30

Institute of Vitreous Enamellers (Midland Section). " Chemical Resisting Enamels" by Mr. A. W. Murdoch at the Birmingham Exchange and Engineering Centre, Stephenson Place, Birmingham 2. 7.30 p.m.

April 11

Institute of Vitreous Enamellers (Scottish Section). Works visit to Alloa Glass Co.

April 28

Institute of Vitreous Enamellers (Southern Section). Annual Dinner at the Connaught Rooms, London, W.C.2. followed by a visit to the theatre.

POLYTHENE SHEETING FOR ELECTRO-PLATING VATS

GIANT polythene sheets produced by Mondart Ltd. of 49 Park Lane, London, W.1 are used to cover electro-plating vats used in the slush mould department of the London and Scandinavian Metallurgical Co. Ltd., Wellington Road, London, S.W.19, where moulds for hollow P.V.C. toys and other articles are manufactured. The vats contain 1,000 gallons of the company's specially-prepared solution and are over six feet in length and present special problems of humidity (the solution is held steady at 40 to 45°C.) and evaporation. The polythene sheeting with its especially inert quality, contends well with conditions of extra-normal humidity, and when condensation occurs, the solution drips back into the vats without contamination.

13th Oil and Colour Chemists Exhibition

THE thirteenth Oil and Colour Chemists exhibition will be held at the Royal Horticultural Society's Old and New Halls on March 6, 7, 8, 9. The exhibition will provide a focus for the technical display of advances in materials, equipment and the technology of those industries supplying the paint, varnish, printing ink, linoleum and allied industries.

An exhibition luncheon will be held at 12.45 p.m. on March 6, at the Criterion Restaurant, Piccadilly Circus, London, W.1. The principal guest will be Sir Cyril Hinshelwood, O.M., D.Sc., F.R.S., president of The Royal Society (1955-60) who will perform the opening ceremony at the entrance to the Old Hall at 3 p.m. on March 6.

Prior to the exhibition dates, all enquiries, requests for brochures and exhibition luncheon tickets, should be made to R. H. Hamblin, M.A., F.C.C.S., General Secretary, Oil and Colour Chemists Association, Wax Chandlers Hall, Gresham Street, London, E.C.2 (Monarch 1439).

An account of the processes and equipment of interest to the metal-finishing industry will be given in the March issue of this Journal.

Latest Developments in PLANT, PROCESSES AND EQUIPMENT

Separating Solids in a Liquid

FIG. 1 shows the Hydrocyclone produced by Liquid-Solid Separations Ltd., 2 Andover Street, London, S.W.3 as a speedy and accurate method of separating or classifying solids suspended in a liquid. The liquid to be processed is injected into the Hydrocyclone under pressure and the rapid rotary motion imparted to it produces a high centrifugal force, which forms two distinct vortices, the outer of which carries the heavier solids to a nozzle in the apex of the unit from which they are discharged together with some liquid, while the lighter solids are entrained in the inner vortex to an axial overflow at the opposite end.

Owing to the very strong shearing forces also produced, the Hydrocyclone is effective even with pulps of high solid concentration or plasticity, and its ability to distinguish between granular particles and those which settle by means of flocculation or other forms of aggregation, makes it useful for cleaning such materials as fibrous pulps.

The unit is of simple construction and consists of a body, normally of cast aluminium or fabricated mild steel, with a lining of special abrasion-resistant rubber. The upper part contains the vortex finder and overflow, and a removable nozzle of rolid rubber is fitted to the apex ; the walls of the nozzle increase in thickness to provide maximum thickness towards the orifice and in the smaller units the rubber body lining is replaceable. The size of the unit selected for a particular application is determined by the fineness of the separation required ; the smaller the diameter of the feed inlet and of the overflow or vortex finder the finer the separation achieved. The apex nozzle controls the proportion of feed rejected as underflow and also its solid concentration. The fineness of separation can also be increased by recycloning the overflow, and the sharpness by recycloning the underflow. Two other factors which affect the size of separation are pressure, the increase of which usually produces finer separation and feed dilution.

The Hydrocyclone is produced in models with capacities ranging from 4 to 1200 gallons per minute and among its potential applications are degritting of cutting, grinding and honing fluids and of rolling mill cooling water.

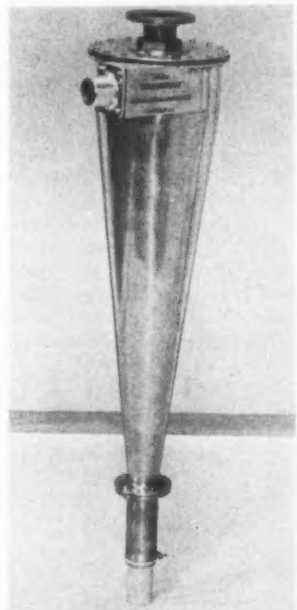


Fig. 1.—Equipment for separating solids from a liquid.

Plating Thickness Meter

NASH and Thompson, Ltd., of Tolworth, Surrey, have manufactured a plating meter based on a design by the British Non-Ferrous Metals Research Association as a means of measuring the thickness of most industrial platings. The coulometric principle entailed involves stripping the plating from a standard area and measuring the integration of time and current density. The operation is simple and speedy, and the meter switches itself off when the stripping action is completed ; the thickness of the plating removed is determined from a dial reading and a multiplying factor. Stripping is effected by means of a solution, with or without agitation, which is placed in a cell on a swing arm placed on the plated surface ; at the same time a current is passed through cell and plating and an in-integrating circuit provides a reading based on the tegration of the current density and the time taken to strip the plating. Readings can be made to an accuracy between 0.000004 in. and 0.0015 in. to an accuracy of ± 5 per cent. The meter is mains operated and the circuits used are all transistorized.

Selective Plating Process

FIG. 2 shows an installation produced by Selectrons Ltd. of 520 Fifth Avenue, New York 36, N.Y. which enables rapid depositions of many different metals and alloys in precise thicknesses and only on areas desired on almost any non-conductive material by means of a special power pack, plating, styluses and non-toxic basic electrolytes. Several sizes of power supplies are available for use at a.c. voltages generally found in industrial plants; d.c. output is variable to suit the engineering needs of the particular application; styluses are manufactured in a number of sizes and shapes for flat, concave and convex surfaces.

The installation can be easily moved from one shop location to another wherever on-the-spot plating capabilities can best be utilized. Readings on totalising ampere-hour meters are readily converted into exact deposit thicknesses since each electrolyte is compounded for a known rate of deposit indicated on the label of the bottle ; more than thirty high-speed plating electrolytes are currently available, including several alloys, cleaners and auxiliary solutions.

A major advantage claimed for the process is that it enables plating of selected areas to be made without extensive masking or stopping off, and without the need for large tanks filled with expensive electrolyte. Instead of immersing the entire article in electrolyte when it is desired to plate only a small area, plating current is sent through the component *via* two leads coming from the rectifier ; the cathode is clamped to the workpiece and the graphite anode, wrapped with cotton, is saturated with the appropriate electrolyte. As the anode is swabbed over the area to be plated, metal is deposited quickly because of the high current densities achieved ; the deposit is said to be dense, free from porosity, and shows unusual adhesion to the substrate.

Fig. 2.—Equipment for selective plating.

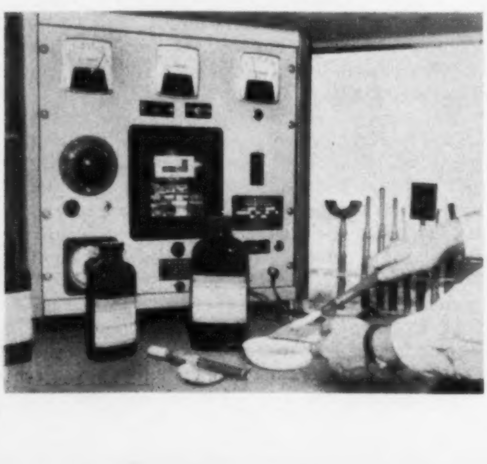


Fig. 3.—Commercial blendor.

High-Speed Blendor

FIG. 3 is the Waring Commercial Blendor, Model CB-4, produced by the Waring Products Corporation, a subsidiary of Dynamics Corporation of America, and marketed by the Waring Division of Winston Electronics Ltd., Shepperton, Middlesex. The blendor consists of a stainless-steel one-gallon container on a zinc die-cast base ; stainless-steel blades in the container operated by an electric motor (250 V. 50 cycles, single phase a.c., 15 amps), rotate at 14,000, 17,000 or 19,000 r.p.m. and enable most foods and concentrates to be mixed, blended, made into puree or liquefied in a few seconds; the blendor will also mix, homogenize and emulsify viscous ingredients over long periods with cool motor running. There are four switch settings, "off," "low," "medium" and "high," the non-toxic carbon-base blade bearing requires no lubrication, the overall height is 23 in. and the weight 36 lb. net. The appliance can be used for paint, ceramics, plastics, paste compounds, etc.

(*Continued in page* 84)

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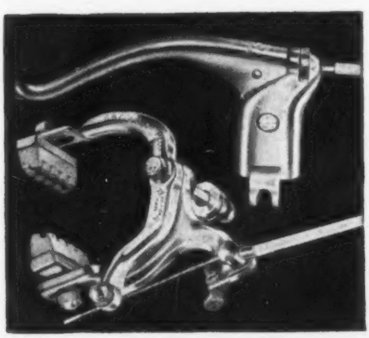

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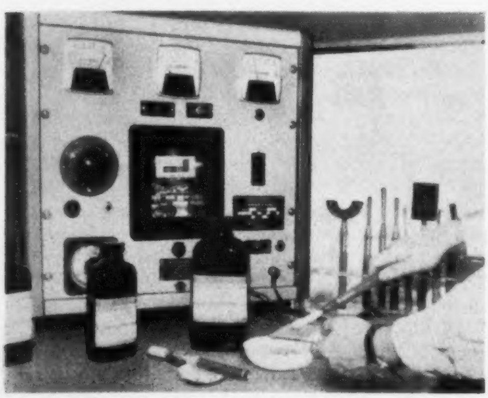

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(*Continued in page* 84)

PVC Finishing Coating Material

THREE grades of PVC finishing coating material which can be applied by spray-brushing, stoving and air drying and will adhere to all metals, wood, brick, concrete, and asbestos, have been produced by the Plasinter Co. Ltd., of Wednesbury, Staffs. The PVC spray-stoving system, ref. MS/HC, has been developed to meet the demands for finishes superior to normal stove-enamelling with similar coating thicknesses, and is suitable for an almost unlimited range of ferrous and non-ferrous metal surfaces ; it can be applied to large and small articles to any desired film thickness from 0.0025 in. to 0.003 in. and upwards. The coating gives a tough flexible film with a hard, glossy, smooth surface and a vitreous-like finish, and a warm feel ; it is suitable for indoor and outdoor use and has a high resistance to ageing and embrittlement. It can be applied over existing paintwork, is unaffected by corrosion, and is resistant to alkalis, alcohol, grease, oils, fats, and a good range of acids. It is a non-conductor of electricity, non-inflammable after processing, has high abrasion resistance, reduces handling noise, can be immersed in boiling water, retains its bright finish with normal cleaning and static electricity has been reduced to a minimum. It is available in a wide range of colours.

PVC spray-brush air drying system, ref. MS/AD, has been developed for surfaces that cannot be stoved and is suitable for ferrous and non-ferrous materials as well as wood, brick, and asbestos. It has the same protective and other properties as the stoving system, including thickness of coating, but the finish is an eggshell gloss. Its field of application is wider than the spray-stoving system since it can be used on the inside and outside of buildings, ships hulls, etc.

The PVC air drying system, ref. MM/AD is a tough coating having all the qualities of the MS/HC and AD systems and a high resistance to acids and chemicals. It is particularly useful where atmospheric corrosion resistance is of major importance such as bakeries, breweries, dairies, distillers, gasworks, plating shops, etc. The finish has a slight orange-peel appearance and is tough, yet resilient with excellent adhesion to most surfaces. The material has a high viscosity heavy bodied solution of plastic so formulated as to enable the application of a continuous coating in thicknesses of 0.005 in. to 0.015 in. or more, free from laps, joints or butts by continuous spraying and without formation of runs. As the efficiency of this kind of coating increases with film thickness, the ultimate thickness will be determined by the degree of protection required.

Unbreakable Protective Spectacles

SAFETY Service Co. Ltd., " Itex " House, Wendover Road, Harlesden, London, N.W.10, have produced spectacles with an unbreakable nylon frame, " Itex " Flexispec, which are claimed to be able to withstand the toughest treatment in any industry and may be bent or twisted yet return instantly to their original shape. The Flexispec weigh only 1 oz. and are fitted with replaceable curved shatterproof lenses which offer complete protection to the wearer ; they are fitted with clear nylon sideshield giving all round visibility and will fit over all types of ordinary spectacles. They comply to the requirements of British Standards No. 2092.

Activated Charcoal Filters

ALFRED Bullows and Sons Ltd., of Long Street, Walsall, Staffs., have produced a range of activated charcoal filters designed for use in compressed air systems where oil in the air stream is not acceptable ; these filters are claimed to be so successful that they not only remove all traces of oil from the air but also eliminate the smell generally associated with oil in aerosol form. Each filter consists of an outer case and lid with a cartridge of activated charcoal which removes oil from the air stream by adsorption and is therefore an expendable item which requires changing at intervals, dependent upon operating conditions. An average normal life of a cartridge element is 1,000 to 1,500 working hours and quick and easy cartridge replacement is one of the key features of the design.

Phenolic Resin for Abrasive Products

" DUREZ Resin No. 19759 " produced by Omni Ltd., 35 Dover Street, London, W.1, is a powdered two-step phenolic resin which in field trials has produced cold press snagging wheels for billet grinding that are said to be remarkably free from radial cracking and show a very high degree of efficiency (ratio of metal removed to wheel wear).

Plating Barrel Improvements

TWO new plating barrel improvements have been produced by the Hanson-Van Winkle-Munning Co. of Church Street, Matawan, N.J. The first is a barrel material, polypropylene, which can withstand plating, cleaning or acid dipping at temperatures up to 200°F. and the second is a type of hanger for belt-driven cylinders that allows the operator to replace worn belts by merely snapping the old belt off its pulley and snapping a new one in its place.

(*Continued in advt. page* 26)

Plant Processes and Equipment

(*Continued from Edit. page* 84)

Immersion Type Electrode Assembly

THE immersion type *p*H electrode assembly (Cat. No. 11460) displayed by W. G. Pye and Co. Ltd., Granta Works, Cambridge, at the recent Physical Society Exhibition, is a fully sealed *p*H electrode unit for use in open tanks, channels or troughs and designed to give the easiest possible maintenance. The electrodes are mounted on a stainless-steel base-plate and sealed with glands, the lower ends being shrouded by a protective cage which is also fabricated from stainless steel. Electrical connexions to the electrode are made from inside a protective housing which forms a completely watertight seal around the base plate; this housing can be raised for maintenance purposes, giving immediate access to the electrodes without disconnexion or disturbance of cables. Housing and extension tubes of various lengths are also in stainless steel and clamping arrangements are remote from the liquid. The electrical leads to the *p*H amplifier are incorporated in a multi-core cable and completely sealed by a water-proof gland at the top of the assembly, which also carries a potassium chloride reservoir. The reservoir supplies the reference electrode and ensures a positive head to prevent electrode contamination.

The industrial flow type *p*H electrode assembly (Cat. No. 11440) is designed for permanent installation in by-pass systems, pipe-lines, etc. and is easily accessible, making it convenient for maintenance, cleaning and replacement. Stainless-steel columns allow the electrode components to be raised and swivelled clear of the chamber for rapid standardization in buffer solution ; the assembly may be joined to glass or metal lines as required with the minimum of installation labour. Process solutions need not come into contact with any metallic parts in their passage through the glass flow chamber.

Glass Fibre Noise Suppressors

MOULDED fibrous glass in specially designed shapes for use to suppress high-frequency noises generated by the compressors of unit air conditioners, is being produced by Fibrous Glass Products, a subsidiary of Pall Corporation, Alpa Plaza, Hicksville, L.I., N.Y. The noise suppressors are made in two halves to assist rapid and simple assembly and are sprayed with a vinyl surface coating to aid handling ; they have an insulation density of 6 lb. per cu. ft., providing a maximum of acoustical insulation with a minimum of weight or space and have replaced pasted insulation in many cases and made possible a reduction in overall costs.

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PLATING SHOP CONTROLLER. A vacancy exists in a large light engineering factory for a man to control a new Plating Plant engaged on high quality precision component finishing. The person envisaged should have a varied background of industrial plating preferably with some chemical qualification and several years practical experience in this field. The situation commands a salary of not less than £1,100 p.a. initially, plus Staff status and superannuation and in view of the importance of this post, advancement to the right capable man is assured. The age limits preferred are 33-45. Write in first instance to Box. No. PS4639, A.K.Advtg., 212a Shaftesbury Ave., London, W.C.2.

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metal finishing journal

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